ECONOMIC REFORMS AND AGRICULTURAL SUPPLY RESPONSE IN JAMAICA

By

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A number of economic reform programs have been undertaken in Jamaica, over the past two decades. Designed largely by the International Monetary Fund (IMF) and the World Bank, these reforms focused on correcting internal policy weaknesses and creating an environment conducive to sustained growth. The reforms emphasized liberal trade and exchange rate regimes, a less intrusive and smaller public sector, and reliance on market forces to determine agricultural prices and quantities.

Against this background, this study investigates the impact of these recent economic reforms on agricultural crop supply responses in Jamaica. The estimation technique used an error correction modeling framework based on

cointegration theory, within an estimation framework developed by Johansen. The results of the crop supply response estimation confirm that there is a long-run relationship between agricultural crop output and price incentives. Most of the estimated crop price elasticities are low, statistically significant, and fall within the range estimated by other studies on Jamaica. The adjustment process of the short-run to the long-run was found to be slow for some crops and higher for others.

Using a counterfactual, which assumed no change in policy regime, fitted series of supply response functions from the pre-reform period were forecasted within a univariate ARMA(p,q) framework and compared to fitted series of supply responses from the reform period. The results are mixed. It was found that the impacts of the economic reforms in Jamaica are crop and time specific. Mean output was higher in the reform period for four of the eight crops analyzed. Higher real price shifts were observed in the reform period for some crops but these price shifts were also accompanied by higher price-variability. This suggests that the pro-competitive effects that were expected to accompany the reforms may have outweighed the stability impulses of administered prices in the pre-reform era.

CHAPTER 1
INTRODUCTION

The past two decades have seen a shift in economic policies throughout Latin American and Caribbean countries. Generally, these policy changes have been in response to debt crises, persistent payments-imbalances, and years of negative and slow growth. By the 1990s a new orthodoxy on development thinking could be discerned. This is manifested in reductions in public sector activities and greater reliance on private sector initiatives and market forces, a departure from the policy regimes of the 1960s and 1970s.

In Jamaica, as elsewhere, the new orthodoxy has influenced economic policies in agriculture. In particular, policies have shifted away from far-reaching government interventions and control, to increased reliance on market signals to allocate resources and form prices. In addition, economy-wide macro-economic policy changes have been made which can potentially influence agricultural incentives, income, and output. Designed largely by the International Monetary Fund (IMF) and the World Bank in consultation with

the Government of Jamaica, these reforms[1] are expected to favor Jamaican agriculture under the presumption by the Bretton Woods institutions that previous policies severely discriminated against the sector. (This point is elaborated in Chapter 2, section 2.4). This study pertains to the impacts that these economic policy reforms have on agricultural supply responses in Jamaica, as the agricultural sector emerges from a heavily regulated sector to one that is more open[2] and liberal. This chapter discusses the problems that this study addresses.

1.1 Background to Jamaica's Economic Reforms

For purposes of this study, the reform period is defined as the years 1980-1999, while the pre-reform period is 1962-1979. The year 1962 is sufficiently far back to facilitate a meaningful analysis of economic policies and conditions that led up to the dramatic changes in policies in the reform period. The reform period marks a re-orientation of economic policy. This change arose from the stabilization programs of the IMF in Jamaica in the late 1970s. It gathered momentum in the 1980s and 1990s in the

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[1] In this study, "policy reforms," "economic policy reforms," "economic reforms," and "structural reforms," are used interchangeably.

[2] Openness is defined here in terms of trade/GDP ratio. A high trade/GDP ratio can coexist with high import tariffs, export subsidies, and non-tariff barriers, signaling a non-liberal trade regime.

form of structural adjustment programs cum reforms for economic liberalization, under the direction of the IMF, the World Bank and other leading external funding agencies, notably the Inter-American Development Bank (IDB) and the United States Agency for International Development (USAID). In effect, therefore, for the purposes of this study, economic reforms refer to the policies stipulated in the stabilization and structural adjustment programs which Jamaica has been pursuing since the late 1970s.

When the People's National Party (PNP) took office in 1972 under Prime Minister Michael Manley, it was under pressure to keep its election campaign promises to increase real wages and government spending, and to reduce social inequalities. The responses of the new administration to this situation, coupled with subsequent external and domestic events, were to plunge the economy into a sustained recession and major disequilibrium. During the previous administration under the Jamaica Labor Party (JLP), the performance of the economy was impressive. GDP growth rates were positive and relatively high (5.1 percent per annum over the 1960-1970 period), inflation was less than five percent per annum and the balance of payments showed modest surpluses (Jefferson, 1972; IMF, 1998). Over the 1970-1980 period, however, real GDP declined by -0.9

percent. In fact, with the exception of a negligible 0.7 percent GDP growth in 1978, negative growth rates were recorded for all other six years between 1974 and 1980. Similarly, in the productive sectors, agricultural value-added growth declined from 6.7 percent in 1970-1972 to -0.4 percent in 1973-1980. For these same periods, declines in growth rates were recorded for services from 9.2 percent to -0.08 percent, manufacturing from 6.7 percent to -4.2 percent, construction from 6.0 to -10.6 percent, and mining from 13.2 percent to 1.3 percent, respectively (Singh, 1995; IMF, 1998).

The external account reflected the production crisis described above. Between 1972 and 1980, the accumulated deficit on the balance of payments was US$679.2 million, compared to an accumulated surplus of US$95 million between 1960 and 1971 (Jamaica, Bank of Jamaica, 1985). Further, the deficit on the current account increased almost three-fold from US$570.2 million in 1962-1970 to US$1,620.0 million in 1972-1980, and the capital account became negative in 1977, signaling capital flight. At the same time, the dwindling net capital inflows could not match the current account deficit. This depleted international reserves, which plummeted sharply from US$103.1 million in 1972 to minus US$461 million in 1980 (Sharpley, 1984). The

foreign exchange shortage harmed the economy given its relative openness and dependence on foreign intermediate imports.

Finally, the inflation rate, which was 4.2 percent per annum over the 1960-1970 period, recorded double-digit rates throughout the following decade. Domestic prices, as measured by the consumer price index, rose sharply, recording an annual increase of 25 percent and 47 percent over the 1974-1975 and 1978-1979 periods respectively (Sharpley, 1984). By the late 1970s economic conditions had deteriorated to such an extent that, when combined with manifest signs of social distress (such as a dramatic increase in violent crimes and emigration of skilled workers), they generated a sense of instability and crises (Stephens and Stephens, 1986; Kaufman, 1985).

The crises indicated a need for policy changes, and it appears that the government was thinking along those lines as reflected in a Stand-by Agreement it negotiated with the IMF just before the December 1976 elections. The Agreement included, *inter alia*, a wage freeze, fiscal restraint and a currency devaluation of 20 to 40 percent (Boyd, 1988). However, in the December 1976 election the PNP was returned to office and the new administration promptly rejected the IMF Stand-by Agreement as being inconsistent with the

mandate obtained in the recent election. Instead, and as a way of avoiding agreements with the IMF (Boyd, 1988), and after significant slippages in the external and domestic accounts (Sharpley, 1984), the government implemented its own adjustment policy measures in January 1977. These included (Boyd, 1988)

(1) The reversal of the previous wage indexation policy;

(2) Implementation of import and exchange controls, a dual exchange rate system and foreign exchange rationing;

(3) Suspension of foreign debts for 18 months; and,

(4) A search for funding from sympathetic governments.

However, it became increasingly clear to the government that in order to attract foreign capital some formal agreement with the IMF was necessary. In this regard, the government signed three agreements with the IMF between August 1977 and June 1979. The first was suspended after four months for failure to meet the stipulated quarterly tests. The second, signed in May 1978, was pursued in all its aspects by the government for a year. Although economic performance under this agreement was poor (Sharpley, 1984; Boyd, 1988), it was re-negotiated in June 1979. However, the agreement collapsed in December 1979

after the government failed to meet the program's performance criteria.

In 1980, in light of increasing social unrest, continued slippages in the fiscal deficits and external accounts, severe foreign exchange shortages, and rising inflation (Sharpley, 1984; Boyd, 1988; Thomas, 1999), Prime Minister Manley called a general election so that the nation could decide on a path of economic development and "what part the IMF should play; or whether it should play any part at all" (Jamaica, API, Manley, 1980). Dubbed "the IMF election", the October 1980 election was won by the strongly pro-IMF JLP, led by Edward Seaga. Expectedly, therefore, both the IMF and the government began negotiations on funding and policies aimed at ameliorating the country's economic and social crises.

The new administration relied heavily on funding from external sources. Several loan agreements were negotiated with the leading collaborating lending institutions, the IMF, World Bank, IDB and USAID which have developed a system of cross-conditionalities on their loans, given their basic set of shared objectives on economic policies and on Jamaica (Anderson and Witter, 1994).

The prescription by the IMF and the World Bank (Fund/Bank) on how best to deal with the economic crisis in

Jamaica was a series of economic policy reforms. These reforms went beyond the expenditure-switching and expenditure-reducing policies which macroeconomic policy would normally prescribe under these circumstances, to include a built-in bias in favor of a more liberal economic system. The latter aimed at, *inter alia*, fiscal discipline, liberalizing the domestic market and the external trade sector, privatizing of State Owned Enterprises (SOEs) and other social services, and generally, greater reliance on market signals to allocate resources. Over all, between 1981 and 1992, IMF financial support totaled US$1,036.9 million (under 10 agreements), and that of the World Bank US$360.4 million (under 8 agreements).

1.2 Problem Statement and Study Justification

The cumulative effect of the reforms mentioned above is that the Jamaican agricultural sector is now expected to operate within an economic framework that differs vastly from that of the 1960s and 1970s. Historically, the sector has played an important role in the economy. Agricultural output to GDP ratio is about eight percent, agricultural food export in total export is approximately 20 percent, and agriculture's share of the total labor force exceeds 26 percent (Davis et al., 1999). Given the importance of agriculture in the economy, how the sector performs in this

new policy environment demands urgent attention. In this study, agricultural sector performance is evaluated in terms of crop supply responses. Quantitative analyses of the impact of these reforms on Jamaican agricultural supply responses are both scarce and generally not particularly robust. In addition, the literature on similar economic reforms in other countries suggests that the outcomes of these reforms are ambiguous, which justifies more empirical work (Khan, 1990).

Additionally, this study is justified on the following grounds. First, the economic reforms have generated major changes in the long-term prospects for the national economy within which agriculture will operate. After two decades a good set of data on these policy reforms is now available which should facilitate empirical research on the impact of these reforms on agricultural crop supply responses. This evaluation can throw light on courses of action which policy makers in Jamaica and elsewhere can consider as they seek to reactivate and sustain long-term growth in the agricultural sector.

Second, while a few studies have analyzed specific aspects of the impact of the economic policy reforms on Jamaican agriculture (Singh, 1995; Anderson and Witter, 1994; Newman and Le Franc, 1994; and Brown, 1994), what is

lacking is an over-all analytically rigorous assessment of agricultural supply responses within the context of the new policy framework as defined by the recent economic reforms.

Finally, analysis of the impact of these reforms on agricultural supply responses is both timely and urgent in light of an on-going debate. A number of writers in the Caribbean and elsewhere have been advancing the view that the kinds of economic reforms implemented in Jamaica and in other countries have harmed agriculture (Anderson and Witter, 1994; Green, 1989; Bates, 1989). In contrast a recent series of studies sponsored by the World Bank suggests that policy reforms similar to Jamaica's should boost agriculture in countries which have traditionally discriminated against the sector (Schiff and Valdés, 1992a; Krueger, 1992).

1.3 Objectives of the study

The general objective of this research is to evaluate the impact of economic reforms on selected agricultural crop supply responses in Jamaica over the 1980-1999 period. The specific objectives are to provide

(1) A statistical evaluation of the performance of the agricultural sector in the pre-reform (1962-1979) and reform (1980-1999) periods.

(2) A descriptive, diagnostic and statistical analysis of the economic reforms that have taken place over the past two decades within the agricultural sector.

(3) An econometric (modeling) evaluation of selected agricultural crop supply responses over the 1962-1999 period, with the number and types of crops chosen for study to be determined by data availability.

(4) A comparative analysis of agricultural crop supply responses in the reform period with a counter-factual, the latter defined as crop supply responses that would have resulted in the absence of the reforms.

1.4 Hypotheses

The following hypotheses are advanced in the study:

(1) Structural reforms significantly improve agricultural supply responses.

(2) Sustained improvements in agricultural supply responses require further broadening and deepening of the reform process.

1.5 Conceptual Issues

Agriculture features prominently in policy discussions when (1) it is believed that agricultural policies and institutions help precipitate an economic problem which

policy makers are addressing; and (2) when agriculture is an important contributor to employment, GDP, export earnings, domestic food supply, and revenue for the government (Binswanger and Deininger, 1997). Various publications by the government of Jamaica suggest that both of these factors have featured prominently in the recent reforms, while (2) was a major consideration in the pre-reform (1962-1979) period. Consequently, the conceptualization is based on two perspectives that are believed to have influenced the design of the policy reforms:

(1) The Jamaican government perspective. From numerous government publications, it would appear that this perspective is clustered around three main goals: (a) increasing food supply; (b) developing rural areas; and (c) increasing agriculture's contribution to the over-all economy, through, *inter alia*, employment, contribution to GDP, and export earnings; and,

(2) The IMF/World Bank perspective, whose focus on the agricultural sector clusters around (a) getting prices right; (b) improving efficiency; and (c) rationalizing public expenditure in the agricultural sector.

These two perspectives are not mutually exclusive. On the contrary, the choice of policies in a particular program package results from extensive discussions between officials of the IMF/World Bank and the Jamaican government. The program policy mix therefore reflects the particular economic situation in the country as well as the preferences of the government (Khan, 1990). Despite this, a review of the literature on Jamaican agricultural policy formation suggests that since the late 1970s the influence of the IMF/World Bank perspective has exceeded the Jamaican government's.

Given the two perspectives mentioned above, and a review of the content of the reforms since the late 1970s, the evidence suggests that the reforms have focused on three inter-related issues of relevance to the agricultural sector: (i) agricultural (inter-sectoral) terms of trade; (ii) agricultural growth, its adjustment, and supply response; and (iii) efficiency in the agricultural sector (Nallari, 1992; Singh, 1995; World Bank, 1996).

Figure 1.1 conceptualizes the Jamaican agricultural sector, dividing the factors impacting agriculture into external (e.g., world prices) and internal. The latter can be separated into those that are exogenous (weather, terrain) and those that are policy induced. Another useful

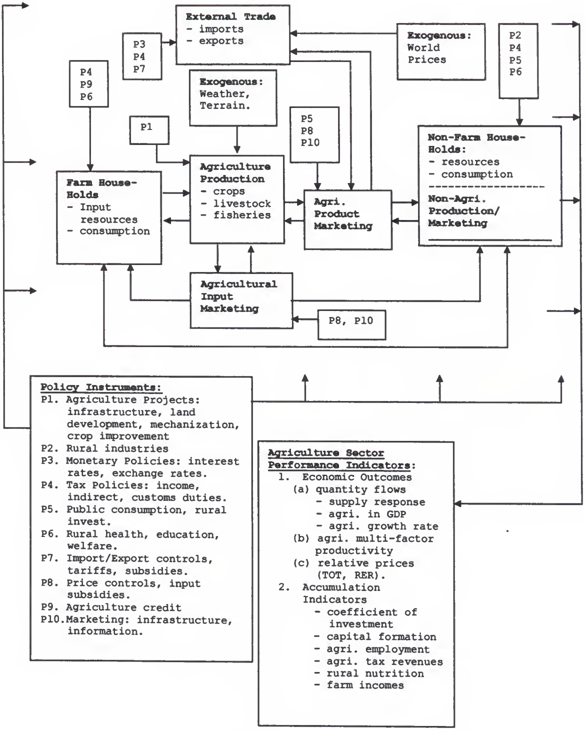

Figure 1.1: Conceptualization of the Jamaican Agricultural Sector.

distinction is between prices and non-price factors (including exogenous shocks) that influence agricultural output and income. At the micro level, the price variables include prices of the particular crops, prices of alternative crops, input prices, and the general price level. Government policies exercise both direct and indirect influence on agricultural prices and thus on agricultural performance. Direct (sectoral) policies such as price ceilings, guaranteed prices and trade taxes/subsidies provide incentives to shift resources among crops and sectors of the economy (Binswanger, 1989). Government policies also can influence output indirectly through macroeconomic (or economy-wide) policies. The most critical components in this regard are fiscal policies and exchange rate policies (Mamingi, 1997).

The terms of trade as a policy variable turns on the hypothesis that if all prices were determined in markets, and effective rates of taxation were equalized across commodities, then agriculture's supply responses, growth, income, and contribution to GDP would be higher compared to situations of negative effective protection of the sector (Schiff and Valdés, 1992b). A negative effective protection of agriculture arises when:

$$(1.1) \qquad \frac{1}{P}\left[\left(P_i - P_i^f\right) + \delta C_i\right] < 0$$

where P is a general price deflator, P_i denotes the producer price of crop i, P_i^f is the free-market price for crop i, and δ is a subsidy to producers as a proportion of cost, C_i. For many developing countries, agricultural pricing policies have consistently kept P_i below P_i^f, and subsidies have not sufficiently counterbalanced this disparity (Schiff and Valdés, 1992b). Given severe budgetary constraints, to achieve at least zero effective protection, the policy implication of (1.1) is to raise the real producer price, $\frac{P_i}{P}$, or to liberalize all markets thereby eliminating the disparity between P_i and P_i^f. In effect, improving agriculture's terms of trade.

The exchange rate sets an upper limit on agricultural export earnings and, when combined with input taxes and subsidies, affects input prices and competing agricultural imports. Changes in the real exchange rate can affect agricultural output and growth by altering the terms of trade between agriculture and non-agricultural sectors. Further, policies that lead to over-valuation of the exchange rate can adversely affect export crops, encourage

rent-seeking activities and generate unproductive uses of resources (Jaeger, 1991).

In addition to the price policies, non-price factors constitute an important influence on agricultural output. These factors reflect the material conditions of production in the agricultural sector. Some of these factors include, *inter alia*, government expenditure and investment in the agricultural sector, construction of rural infrastructure (roads, drainage and irrigation works), extension services, rural credit institutions, and dissemination of relevant scientific information to farmers. The aim of agricultural sector-specific programs is to find a mix of policies for increasing efficiency and productivity in the sector. It is assumed that these two outcomes are necessary (if not sufficient) conditions for increasing agricultural output and growth by reducing costs of production and/or increasing product prices. These policies focus on using public investment in agriculture efficiently, reducing marketing and transport bottlenecks, improving agricultural extension services, health and education (capital formation in agriculture), rationalizing input prices, and enhancing the efficiency of parastatals in the agriculture sector.

Behrman (1990) has advanced an important perspective on the channels through which policies affect performance

indicators. He argues that analysis of the impact of policy reforms on performance indicators must explicitly consider the conduits through which the effects of the policies are transmitted to the observed (or desired) outcome. These "meso-level" variables, identified as markets (product, input and financial) and infrastructure (economic and social), are the interface between the policies (sector-specific and economy-wide) and targets. In Figure 1.1, for example, various policies, P_i, $i = 1,2,3,...10$, are identified. Some are macroeconomic (e.g., monetary policies and exchange rate adjustments), whereas others are sector specific (e.g., agriculture credit, tariff reductions in the trade sector and elimination of price controls in agriculture). These policies are then combined to achieve specific targets, either at the sectoral or macroeconomic levels.

Behrman (1990) emphasizes, however, that the meso-level variables condition the effectiveness of policies on the target variables and that analyses of policy impacts must also evaluate how policies have influenced these meso-level variables. For example, if poor transportation, lack of effective irrigation, or in-efficient research and extension services restrain farmers' responses to higher

prices, then improving these meso-level variables may do more for the farmer than price increases (Chhibber, 1989).

The influence of the factors mentioned above on agricultural supply responses has been well documented in the empirical literature. However, the recent economic reforms have had an enduring effect on these factors. This points to an important issue raised in the literature, viz., how to measure the magnitude of reforms (IDB, 1997). Economic statistics such as exchange rate differentials, inflation rates, tax changes and so on deal with outcomes rather than the policies that gave rise to them. In order to address this issue, structural policy indexes have been constructed by Lora (1997) and others.

The index by Lora (1997) was constructed for twenty countries in Latin America and the Caribbean. This index seeks to measure the extent of market freedom accorded to economic policies in areas of trade, tax, finance, privatization and labor. In each of these areas indices of market freedom are identified. For example, in trade policy the indices are average tariffs and tariff spreads; in tax policy the indices include, *inter alia*, tax rates on companies and on individuals; and on financial policy, indices include freedom of interest rates on deposits, loans, reserves on bank deposits, etc. (IDB, 1997). The

structural policy index is a simple average of the indices in the five areas. The index can range from 0 to 1, based on the worst and best observations respectively, on market freedom in the country. Further, the index is an important indicator of the extent to which countries are departing from past ways of operating their economies. Jamaica's structural policy index has shown continuous movement towards market freedom, increasing from 0.426 in 1985 to 0.684 in 1995. These index values are higher than the average reported for the twenty Latin American and Caribbean countries in the sample (Lora, 1997).

1.6 Procedural and Methodological Considerations

In approaching the general and specific objectives of the study, critical analysis of the Jamaican agricultural sector's performance is first undertaken. To achieve the general objectives and, more specifically, objectives (2), (3) and (4), requires four specific tasks. The first task is to identify and evaluate the structural reforms undertaken since the late 1970s. Both the stabilization and the structural reform policies are evaluated according to their (1) theoretical bases; (2) breath of vision; and (3) logical consistency. Second, supply response models are developed and estimated. Finally, specific objective (4) is

addressed within the context of simulating an alternative path to that of the reforms.

Any appraisal of the reforms must compare their impacts not to the pre-reform indicators but rather to some specified, hypothetical alternative. This requires some simulation exercises. The idea here is to generate simulated time series over the reform period for the performance indicators. The simulated series then constitute the counterfactual to which the actual outcomes in the reform period are compared. For the counterfactuals, at least three scenarios appear to be logical extensions. Scenario 1 assumes that the policies pursued over the pre-reform period continued into the reform period, i.e., that the reforms over the 1980-1999 period were not instituted. Scenario 2 assumes policies based on the Jamaican government's critique of the IMF/World Bank programs were implemented. Finally, Scenario 3 assumes that IMF/World Bank assistance came with no conditionalities. These components form the basis of the data series for the simulation exercise.

The three scenarios appear logical and plausible options given (1) the initial defiance by the government of the mandated reforms in the late 1970s; (2) the frequent failures to meet conditionality tests because the reforms

were not implemented; and (3) government's own protestations over the years of what are considered "acceptable" reforms. While numerous instances of disagreements exist between the Jamaican government and the IMF/World bank with respect to appropriate reform policies, the clearest statement to this effect is captured in the following quotation:

> Even though lender and borrower therefore shared the common concern regarding the need for economic reform, there is still much debate about appropriate social policies and about the specific effects of manipulating major economic variables such as exchange rates and interest rates. This was illustrated by the lengthy and tortuous negotiations between the government of Jamaica and the IDB and World Bank on the 1989-90 Agricultural Sector Adjustment Loan. (Anderson and Witter, 1994, p.14)

1.7 Summary

It is generally believed that developing countries have historically discriminated against their agricultural sectors in favor of industrial development. It is further felt that policies that reverse that discrimination should boost agricultural output and income. Over the past two decades far-reaching economic reforms have been undertaken in Jamaica leading to a new economic framework within which the agricultural sector must now operate. This study seeks to assess the impact of these reforms on agriculture crop supply responses, an undertaking that is both timely and

urgent given the importance of the sector in the economy and the absence of rigorous analytical studies on the Jamaican experience with these reforms.

CHAPTER 2
ECONOMIC STRUCTURE, GROWTH, AND POLICY REFORMS IN THE JAMAICAN ECONOMY, 1962-1999

It is useful, at the outset, to situate the discussions in this chapter against the backdrop of three distinct phases of economic policy that characterize the economic history of Jamaica over the period 1962-1999. In the first phase, 1962-1972, the Jamaica Labor Party (JLP) emphasized free markets. However, Bonnick (1984) argues that despite the rhetoric of economic liberalism, in reality the government pursued an import-substitution (IS) strategy based on protectionism, trade restrictions, and price controls.

In the second phase, 1972-1980, the People's National Party (PNP) under Prime Minister Michael Manley pursued economic populism and state directed control (dirigisme) in an effort to build democratic socialism. This phase was marked by extensive government intervention, which included nationalization of major industries, price controls, and subsidization of basic foods and some agricultural imported inputs. These policies made significant demands on national resources and created a large bureaucratic economic

structure. Consequently, the government was unable to respond to the crisis in the world economy in the mid-1970s, and was forced to approach the IMF for stabilization funding in 1977.

The third phase, 1980-present, is directly linked to the policies of the previous phases, particularly the 1977 IMF stabilization funding. Phase three can be viewed as having two sub-phases. The first is the return of the JLP to government in 1980-1989 and the implementation of various Fund/Bank stabilization and structural adjustment programs. The second, 1989-present, marks the return to government by the PNP, the continuation of the market led policies of the preceding JLP administration, but more importantly, the intensification of the country's commitment to liberalization of the economy. The rest of this chapter is organized as follows: Section 2.1 provides an overview of the structure of the economy and its growth performance. Section 2.2 highlights trends and policies in the agriculture sector. Sector 2.3 describes the economic reforms, and Section 2.4 provides a summary of issues raised in this chapter.

2.1 Structure of the Economy and Economic Growth: An Overview

The relative contribution of economic sectors to GDP in Jamaica has not changed much over the past two decades. The data presented in Table 2.1 and Figure 2.1 show that agriculture's share has been fairly stable, ranging from an average of 8.4 percent over the period 1969-1979 to 8.0 percent over 1990-1998. Although agricultural contribution to GDP is lower than that of the other sectors, these comparatively small percentage contributions are deceptive. Davis et al. (1999) have shown that the sector plays an important part in the country's employment, food production, and foreign exchange earnings.

The industrial sector, which includes mining, manufacturing and construction, contributed on average 39.1 percent to GDP in the period 1969-1979 but declined to 37.3 percent in 1990-1998. The manufacturing sub-sector also shows a decline from 18.4 percent in 1969-1979 to 16.3 percent in 1990-1998. Finally, services constitute the largest sector of the Jamaican economy, accounting for over 50 percent of GDP over the period 1969-1998. Its contribution to real GDP has increased from 48.5 percent in 1969-1979 to 54.7 percent in 1990-1998.

Table 2.1: Sectoral Contribution to Real Gross Domestic Product (Period Averages, Percentage).

	1969-79	1980-89	1990-98	1969-98
Agriculture	8.4	6.4	8.0	7.6
Industry	39.1	34.5	37.3	37.0
Manufacturing	18.4	20.9	16.3	17.1
Services	48.5	59.1	54.7	53.9

Source: Computed using data from Jamaica, Planning Institute of Jamaica (various issues).
Note: The 1998 data used were preliminary estimates.

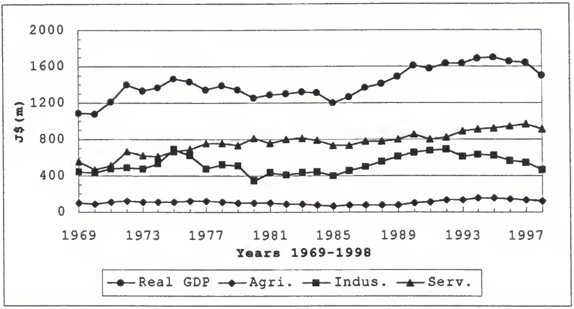

Figure 2.1: GDP and Sectoral Contribution to GDP in Constant 1995 Dollars.

Real sectoral and GDP growth rates are estimated and shown in Table 2.2. The estimation uses a log-linear model, $Y_t = \alpha_0 + \beta * Time + \epsilon_t$, and corrected for autocorrelation whenever it exists. Over the 1969-1998 period, growth rates were positive but consistently low, while sub-period growth reveal mixed results. GDP growth rates were just over two

Table 2.2: GDP and Sectoral Growth (1995=100) (Percentage).

	1969-79	1980-89	1990-98	1969-98
GDP	2.3[a]	2.4[b]	-0.2	1.1[b]
Agriculture	-0.3	1.1	2.3[b]	0.6[b]
Industry	0.9	4.3[b]	-3.8[a]	0.8[a]
Services	4.6[a]	0.1	2.4[b]	1.6[a]

Source: Computed using data from Jamaica, Planning Institute of Jamaica (various issues).
Note: The 1998 data used were preliminary estimates. [a], [b], indicate statistical significance at the five and 10 percent levels, respectively.

percent in the 1969-1979 and 1980-1989 periods. Services growth was reduced from 4.6 percent over 1969-1979 to 2.4 percent over 1990-1998, and was insignificant over the 1980-1989 period. Industrial growth, which was 4.3 percent in the 1980-1989 period, declined significantly to -3.8 percent over the 1990-1998 period. Agriculture growth over the 1990-1998 period was 2.3 percent, compared to its insignificant growth in the two previous sub-periods. Over the entire 1969-1998 period agriculture and industry recorded less than one percent growth, while GDP and services grew just over one percent, respectively.

These periodic growth rates mask the highly volatile annual growth rates in these economic series as shown in Figures 2.2 and 2.3. Over the period 1969-1998, annual growth rates for GDP ranged between -9.0 and 13.0 percent, and were negative in 12 of the 30 years. For the

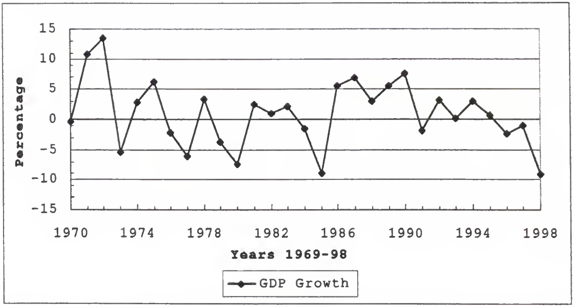

Figure 2.2: GDP Growth (Percentage Change Over Previous Year, 1995=100).

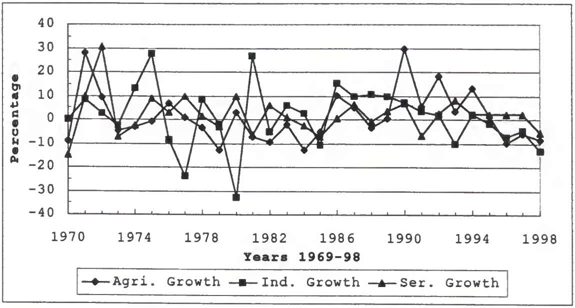

Figure 2.3: Growth of Total Agriculture, Industry and Services (Percentage Change over Previous Year, 1995=100).

1969-1998 period, agriculture growth rates ranged between -12.6 and 29.3 percent, and were negative in 15 years.

Similar annual volatilities characterize the industrial and services growth rate series.

2.2 Output Trends and Policies in Jamaican Agriculture

The growth rates of volume indexes for total agriculture and broad aggregates (food, crops, livestock and cereals) and graphs for these series are shown in Table 2.3 and Figures 2.4 and 2.5. With the exception of the cereals index, which declined over 1971-1998 at an annual rate of -3.2 percent, the other indexes grew but at less than two percent over the 1971-1998 period.

Table 2.3: Growth Rates of Total Agricultural and Broad Agricultural Aggregate Indexes.

	1971-79	1980-89	1990-98	1971-98
Total Agriculture	1.6[a]	1.7	1.9[a]	1.7[a]
Food	1.6[a]	1.6	1.9[a]	1.7[a]
Crops	2.6[b]	1.5[a]	-3.6	1.7[a]
Livestock	1.6[a]	-16.5	0.7	1.3[a]
Cereals	16.9[a]	-9.0	-4.5[b]	-3.2[b]

Source: Computed using data from Food and Agriculture Organization, FAO Production Yearbook (various issues).
[a], [b], indicate statistical significance at five and ten percent levels, respectively.

The composition of agricultural output is shown in Table 2.4. Export agriculture, domestic agriculture, and livestock, forestry and fishing constitute the aggregative components of agriculture in GDP. The data in Table 2.5 and the graph in Figure 2.6 show that domestic agriculture

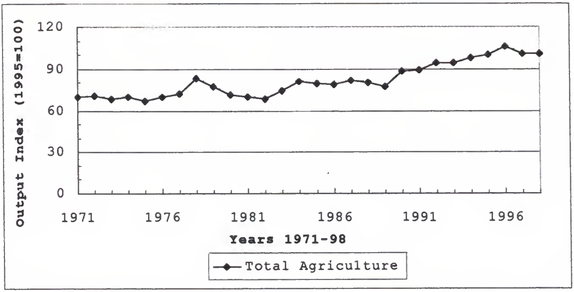

Figure 2.4: Total Agricultural Output Index (1995=100).

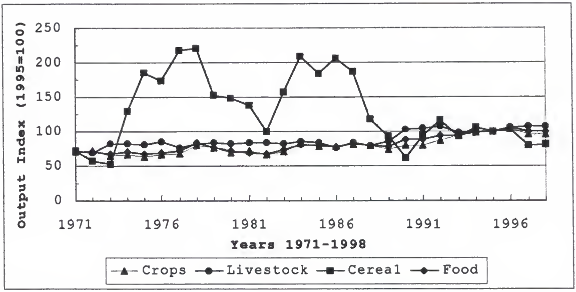

Figure 2.5: Output Indexes for Broad Agricultural Aggregates (1995=100).

Table 2.4: Composition of Agricultural Output (J$M, 1995=100), Selected Years.

Agriculture and Sub-sectors	1969	1975	1980	1985	1990	1995	1998
Total Agriculture	95.9	105.9	101.3	72.2	104.4	154.4	120.4
Export Agriculture	34.3	25.9	14.8	13.9	13.6	15.4	12.3
Sugar Cane	22.6	17.7	9.9	7.8	9.2	9.4	7.9
Other Main Exports	11.6	8.2	4.8	6.1	4.4	5.9	4.4
Domestic Agriculture	33.0	47.1	56.9	38.0	66.2	114.5	82.8
Root Crops	14.4	26.9	25.3	14.6	35.1	62.8	42.7
Other Primary Products	18.6	20.2	31.7	23.4	31.1	51.7	40.1
Livestock, Forestry & Fishing	28.6	32.9	29.5	20.3	24.6	24.5	25.3

Source: Jamaica, Planning Institute of Jamaica (various issues).

Table 2.5: Agriculture Sub-sectors as a Percentage of Total Agriculture (Period Averages).

Agriculture Sub-sectors	1969-79	1980-89	1990-98	1969-98
Export Agriculture	23.47 (5.50)	15.95 (2.24)	11.21 (1.46)	7.29 (6.26)
Domestic Agriculture	44.78 (5.32)	57.21 (6.35)	68.79 (3.62)	56.13 (11.17)
Livestock, Forestry & Fishing	31.73 (1.35)	26.85 (4.49)	20.03 (2.50)	26.59 (5.65)

Source: Computed using data from Jamaica, Planning Institute of Jamaica (various issues).
Note: Figures in parentheses are standard deviation.

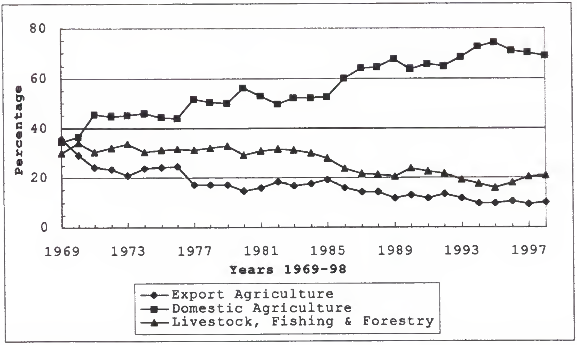

Figure 2.6: Sub-sectors as a Proportion of Agriculture.

constitutes the largest proportion of total agriculture in the 1969-1998 period and other sub-periods. In 1969-1979 the domestic agriculture sub-sector averaged 44.8 percent in total agriculture and increased to 68.8 percent in 1990-1998. Both of the other two sub-sectors, export agriculture and livestock, forestry and fishing, have declined over the period 1990-1998 compared to the two previous decades. In terms of growth rates, Table 2.6 shows that domestic agriculture and its sub-groups are the only sub-sectors within the agri-sub-sector that have positive growth rates over the 1969-1998 period. This has compensated somewhat for the negative and low growth in the other agriculture sub-sectors.

Table 2.6: Growth Rates of Agricultural Components (Percentage).

Agriculture Sub-sectors	1969-79	1980-89	1990-98	1969-98
Export Agriculture	-4.4[a]	-1.3[b]	-4.1[b]	-2.1[a]
Sugar	-4.2[a]	-2.6[a]	-5.4[a]	-2.0[a]
Other main exports	-4.6[a]	1.3	1.0	-2.7[a]
Domestic Agriculture	1.8	11.2[a]	25.6[a]	2.6[a]
Root crops	-2.7	19.7[a]	-1.2[b]	2.6[b]
Other domestic crops	4.0[a]	3.4[b]	-1.4[b]	2.7[a]
Livestock, forestry, & fishing	-1.5	-3.3[a]	0.1	-1.7[a]

Source: Computed using data from Jamaica, Planning Institute of Jamaica (various issues).
[a], [b], indicate statistical significance at the five and ten percent levels, respectively.

The stagnation of agriculture in Jamaica, which can be inferred from the growth rates in Table 2.6 reflects, to a large degree, the state of the agricultural sectors in many less developing countries (LDCs). A plausible explanation for this, is that the development literature in the 1950s and 1960s viewed agriculture as a static sector, from which resources could be shifted to promote industry, considered as the dynamic sector. To a large extent, this view has influenced the kinds of agricultural policies that have been pursued in the past by LDCs. In this regard, Schiff and Valdés (1992a, p.59) state:

> In many developing countries, the high rate of agricultural taxation has been part of an explicit or implicit policy of industrialization-led growth, justified in part by the belief that industry was the dynamic sector while agriculture was static and not very responsive to incentives. That means that economic growth could be accelerated by shifting

resources from agriculture to industry, by taxing agriculture directly, and by protecting the industrial sector.

Many governments in the developing countries have intervened in their agricultural sectors, both directly through agricultural sector policies, and indirectly, through economy-wide policies such as industrial protection. Direct interventions take numerous forms. Some of these include procurement measures (e.g., government marketing boards as sole buyers of agricultural output, and suppliers of major agricultural input); quotas and direct taxation on various agricultural export crops; subsidies on farm credit and farm inputs; and quantitative restrictions and tariffs on imported agricultural imports. While some of the direct interventions have benefited agricultural producers, some are tantamount to an implicit tax on agriculture, depressing farmgate prices and farm incomes below levels that would otherwise prevail (Schiff and Valdés, 1992a). Indirect forms of interventions affect agricultural production incentives via macroeconomic policies (e.g., overvaluation of the exchange rate) and industrial protection policies (Krueger, 1992).

Various measures have been employed by the Jamaican government to extract surpluses from the agricultural sector. These include taxing agricultural exports,

controlling farmgate prices by the state marketing boards, over valuating exchange rates and reducing internal agricultural terms of trade relative to manufacturing. Studies by Gafar (1980, 1997) and Pollard and Graham (1985) strongly support this proposition. Table 2.7 shows that

Table 2.7: Average Rates of Growth of Farmgate and F.O.B. Prices, Output and the Nominal Protection Coefficient (NPC) for the Period 1970-1978, Jamaica.

	Growth Rates (%)1970-78 [a]			
Commodities	Farmgate Prices	F.O.B. Prices	Output	Nominal Protection Coefficient [b]
Sugar Cane	-1.25	4.13	-2.90	0.82
Banana	5.06	7.77	-7.43	0.77
Cocoa	1.64	14.06	-0.54	0.72
Coffee	9.80	8.34	2.02	0.61
Coconut	7.06	4.67	-21.00	n.a.

[a] Adapted from Pollard and Graham (1985), Table 2.
[b] Based on the data in Pollard and Graham (1985), Table 4 for 1970-1979. The NPC is defined as the ratio of farmgate prices (P_F) to F.O.B. prices (P_W) received minus marketing and processing costs (C): $NPC = P_F / (P_W - C)$.

over the 1970-1978 period, the nominal protection coefficient (NPC), for Jamaican agriculture was less than one, indicating the extent to which the sector was taxed. For example, a NPC of 0.82 means that the commodity is taxed at a rate of 18 percent. Subtracting one from the NPC gives the nominal protection rate, NPR, which, according to Table 2.7, is negative, suggesting that producers of the crops reported were not supported, but were taxed instead.

It should be emphasized also, that developing countries have a tendency to overvalue their domestic currencies, so that the official exchange rates used to calculate the NPC overstate internal prices. Hence government taxation of agriculture is even greater than is usually captured by the NPC (Gardner, 1987).

More recent data compiled for this study also support the proposition that Jamaican agriculture has been taxed. Table 2.8 reports on the net barter and income terms of trade between agriculture and manufacturing for Jamaica. The net barter terms of trade, N, is defined here as $N = \frac{P_A}{P_M}$, where P_A and P_M are the price indexes of agriculture and manufacturing, respectively. Values of N greater than one indicate that prices of agricultural commodities have risen relative to those in manufacturing (Tsakok, 1990). The estimates in Table 2.8 reveal that over the 1966-1978 and 1989-1999 periods, the net barter terms of trade were unfavorable to Jamaican agriculture, but were favorable over the decade 1979-1988.

Although the net barter terms of trade may move against agriculture, the sector can still increase its purchasing power if agricultural output increases proportionately more than the decrease in agricultural prices.

The purchasing power of agriculture is captured in the net income terms of trade, I, estimated as: $I = \frac{P_A}{P_M} \times Q_A$, where Q_A is the agricultural output index. The index I is therefore the net barter terms of trade adjusted for marketed amounts. Increases in I indicate a rising purchasing power of agriculture for buying manufactured goods (Tsakok, 1990). The data in Table 2.8 suggest that agriculture's ability to purchase manufactured goods have peaked in the 1979-1988 period.

Table 2.8: Net Barter Terms of Trade and Agricultural Income Terms of Trade (1980=100; Period Averages).

	1966-78	1979-88	1989-98
Net Barter Terms of Trade	0.60	1.39	0.86
Income Terms of Trade	58.20	159.18	134.03

Source: Compiled by author.

2.3 The Economic Reforms

After the late 1970s, Jamaica undertook major changes in economic policies, both sector-specific and economy-wide. These policy changes have been an integral part of the conditionalities usually attached to program packages by external funding agencies. The reforms vary in intensity, both inter-temporally and in terms of the areas in which policy reforms were enacted, such as foreign trade, taxation, and liberalization measures. Underlying

the reforms has been a conviction by funding agencies that freer markets allow for a more productive and efficient use of scarce resources, a condition not necessarily accepted uncritically by the Jamaican government. Nevertheless, a number of market restrictions were eliminated, regulations deemed necessary were simplified and made more transparent, and private enterprises were encouraged. The most conspicuous reforms were the liberalization efforts to facilitate foreign trade and financing activities through exchange rate and tariff adjustments.

The reform period, 1980-1999, has been punctuated by successive IMF/World Bank stabilization and structural adjustment programs, as well as programs financed by other international funding agencies. The stabilization and structural adjustment programs of the IMF and the World Bank for Jamaica were developed as programs of policy reforms, aimed at reversing, within a few years, the economic crisis in the country. Three facets of this crisis emphasized in the IMF/World Bank literature are structural factors, external factors and poor domestic policies, including an anti-agricultural bias in pricing policies. However, it is a matter of public record that these IMF/World Bank reforms have been resisted by the Jamaican government at various times, and have been hotly debated in

the popular media regarding the social impacts of externally imposed structural adjustment programs.

Despite this apparent dissatisfaction, the government has utilized operational policies along the lines of those prescribed by the Bretton Woods institutions. While in principle the early reforms were aimed at stabilizing the economy, from the outset there was a built-in bias in the policies for a more liberalized economic system. For example, the three year Extended Fund Facility (EFF), which the Jamaican government signed with the IMF in May 1978, contained specific conditions for exchange rate devaluation as well as the liberalization of domestic prices (Boyd, 1988). More extensive economic reforms were advanced by the new administration under Prime Minister Edward Seaga who held office from 1980-1989.

Under the 1982 and 1983 structural adjustment programs, quantitative restrictions (QR), on trade were replaced by tariff equivalents, and by 1984 all QRs were eliminated. Exchange rate devaluation was pursued in 1984-1985, followed by the unification of the official and parallel rates. At the same time, the government began to reduce the public sector via the divestment of state owned enterprises (SOEs).

The 1990s witnessed the most protracted reforms aimed at deregulation and liberalization of the Jamaican economy. The PNP, which took office in 1989 under Prime Minister Michael Manley, had campaigned in the general elections on a platform similar to the JLP, vowing to continue the JLP's market oriented policies. This was an opportunity for a fresh departure for the PNP, which was noted for its previous support for democratic socialism and extensive government intervention. Garrity (1996, p.52) argues that

> …the Manley-led government made the decision in 1990 to truly embrace the market and proceed with economic liberalization reforms. For Manley…[t]o continue the reforms of the previous JLP government would not be sufficient to bring about the needed structural changes, nor were there sufficient resources to continue the previous reforms….

Based on the limited available options, Manley's commitment to the liberalization process represented a turning point in state-society relations in Jamaica. In particular, the administration sought an accommodative pattern of governance between state and social actors by energizing the private sector. In this sense, the liberalization process can be viewed as "state-sponsored disengagement from a command role in the economy … and the creation of an enabling environment for private sector-led growth and development." (Garrity, 1996, p.52)

Against this background, the sectoral adjustment loan, which the government signed with the World Bank in 1989, focused on liberalizing the agriculture sector along the following lines:

(1) Deregulation of the coffee and cocoa boards by 1990;

(2) Shifts in government focus from production and markets to support services and infrastructure;

(3) Continuation of the divestment of agro-enterprises (e.g., sugar);

(4) Elimination of subsidies on agricultural credit;

(5) Reduction of tariffs; and

(6) Elimination of the Generalized Food Subsidies;

As a result, by 1991 the generalized food subsidies were eliminated, and complete liberalization of the exchange market and credit interest rate were achieved. Consequently, the overall liberalization process, since the first agreement with the IMF in 1977, opened markets to more competition and reduced the role of the public sector.

As would be expected, the conditions that accompanied the loans from the Bretton Woods Institutions involved reforms at both the macroeconomic and the sectoral levels. Figure 2.7 is a schematic presentation of the kinds of economic reforms and a partial list of specific tasks undertaken since the late 1970s. For convenience, the

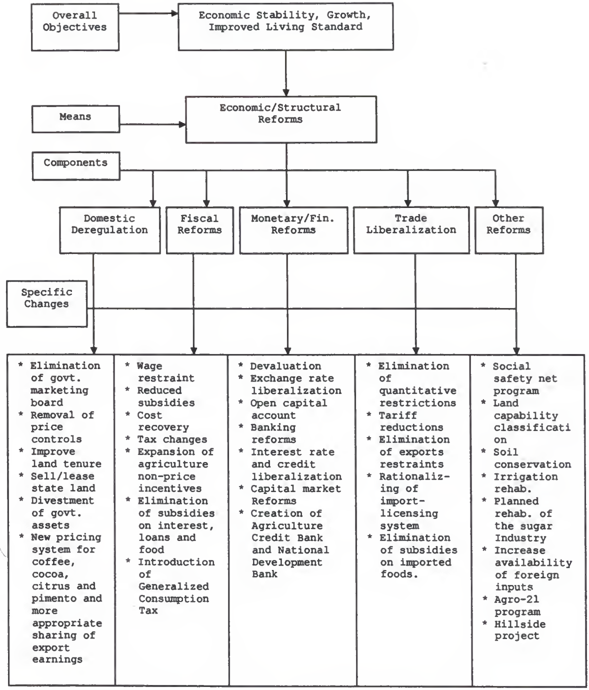

Figure 2.7: Selected Economic Policy Reforms in Jamaica, 1977-98.

policy reforms are organized into five blocks: (1) Domestic Deregulation; (2) Fiscal Reforms; (3) Monetary/Financial Reforms; (4) Trade Liberalization and (5) Other Reforms. Within each block, specific tasks are listed, reflecting implicitly and explicitly policy changes, which seek to enhance the role of market forces, encourage private sector initiatives and reduce government regulation and intervention in the economy. It is interesting to note that in spite of intense criticisms regarding the reforms' lack of success in producing the economic recovery predicted by its proponents, the trend of economic reforms has not been reversed in periods of economic stress. Such periods have instead been met with the broadening and deepening of reform efforts.

Table 2.9 shows selected economic statistics in the pre-reform and reform periods in Jamaica. In the area of trade, average tariffs in 1986 were 56 percent but fell to 11 percent in 1995. Exchange rate systems have been an important policy instrument in Jamaica to establish restrictions on capital outflows and restrictions for repatriating export revenues and foreign exchange. Following the exchange rate liberalization, many of these restrictions have been dismantled. As evidence of the process of exchange rate unification and deregulation,

Table 2.9 shows that the exchange rate differential (i.e., the difference between the average market price for foreign exchange--inclusive of transaction costs and exchange rate taxes--and the official rate) was 25 percent in 1986 but fell to 5 percent in 1995.

Table 2.9: Outcomes of Economic Reform Policies in Jamaica, 1986 vs. 1995.

				Maximum Tax Rate				Structural Policy	
Tariff Reduction		Exchange Differential		Companies		Individuals		Index, I	
Net aver. Tariffs %		Percent		Percent		Percent		0<I<1	
1986	1995	1986	1995	1986	1995	1986	1995	1985	1995
56	11	25	5	45	32	50	25	0.402	0.684

Source: Adapted from IDB (1997).

In the area of tax reforms, Jamaica adopted various changes aimed at administrative simplicity and ease of tax collection. Taxes for companies were reduced from 45 percent in 1986 to 32 percent in 1995. The maximum taxes for individuals were reduced from 50 percent to 25 percent over the same period. Finally, the structural policy index, which is a summary statistic of the extent to which market forces are allowed to operate in the economy, increased from 0.402 in 1985 to 0.684 in 1995.

2.4 Summary

The evidence presented in this chapter suggests that the direction of change of economic structure of the Jamaican economy that began around 1980 continued over the past two decades. Over the period 1966-1998, growth rates of GDP and economic sectors were low but positive. With few exceptions, sectoral growth rates in the reform period, 1980-1999, were higher than in the pre-reform (1962-1979) period.

Some structural change within the agricultural sector was discerned from the data. In particular, export agriculture declined relative to other agri-sub-sectors. Domestic agriculture recorded impressive growth, and it is this agri-sub-sector's overall growth performance that partially compensated for the negative and low growth in the other agri-sub-sectors. Significant economic reforms were implemented, and analysis of their impact on agriculture will be undertaken in a later chapter.

CHAPTER 3
METHODOLOGICAL AND EMPIRICAL ISSUES IN ECONOMIC REFORMS AND SUPPLY RESPONSE

The purpose of this chapter is four-fold. First, it reviews the methods that have been used in the literature to analyze the impact of economic reforms in developing countries. Second, it reviews the literature on supply response analysis. Third, it develops a crop supply response model for Jamaica; and finally, it presents the data sources for the analysis.

3.1 Review of the Economic Reform Literature

In this review of the economic reform literature two sets of issues are addressed. First, attention is directed at the way the economic reforms are conceptualized. Second, the analytical methods used to evaluate the impact of the reforms are examined.

One of the most challenging problems in capturing the impact of economic reforms on target variables is how to isolate the effect of each of the reforms undertaken. Since the reforms were undertaken in various areas (trade reforms, fiscal/monetary reforms, etc), at different points in time, and with varying levels of intensities, their

effects on particular variables in the economy become compounding and difficult to isolate. Khan (1990) argues that it is theoretically and empirically difficult to link all the policy reform measures to the ultimate targets of the policies. Hence most studies have attempted to assess the effects of the overall policy package on particular target outcomes. This is the thrust of the studies by Chadha et al. (1998), and some of the studies in Tshibaka (1998), Campbell and Stein (1991), La Guerre (1994), Valdés and Muir-Leresche (1993), Commander (1989) and Weeks (1995). In these studies, neither the precise nature of the underlying economic relationships, nor the specific policies adopted are made explicit. Instead, the attention is on whether or not the program package, which in effect gives rise to a particular policy environment, has been "effective" in the sense of achieving broad macroeconomic objectives (Khan, 1990).

Most of the studies reviewed proceeded from the premise that the economic reforms originated from the conditionalities that accompanied Fund/Bank-supported packages. In all country experiences the problem of economic instability provided the initial imperative to seek IMF assistance, which, when it came took the form of stabilization policies. However, in most of the studies

reviewed the stabilization policies are treated *en passant*, or not at all, and instead attention is focused exclusively on economic outcomes associated with structural adjustment[3].

For most developing countries that have been pursuing the Fund/Bank economic programs, the last decade has been one in which the reforms have intensified the process of liberalizing the economic system. A frequently raised question with respect to Fund/Bank-supported structural adjustment programs *cum* structural reforms for economic liberalization, has been whether these programs are effective in achieving stated economic objectives. A second and related question is how to measure the effects of these reform policies on the target variables identified in the programs. With respect to this latter question, Guitián (1981) has argued that economic performance under a policy package should be compared to a counterfactual. The latter is defined as economic outcomes that would have taken place in the absence of the program package. The concept of a counterfactual is intuitively appealing and is a standard yardstick widely used in economics to measure the impact of policy interventions. Since the counterfactual is

[3] Stabilization policies are designed to put the economy back on its equilibrium path, whereas, structural adjustment policies aim at putting the economy on a new (higher) equilibrium.

unobservable, it has to be estimated, hence alternative methodologies used to evaluate the program effects are judged in terms of their estimates of the counterfactual.

Although the preceding two questions have generated a large body of literature over the past two decades, there is little consensus in the economics profession either about the impact of past programs on target variables, or about how to estimate the effects of program packages (Khan, 1990). With respect to measuring the impact of reforms, there are three main approaches that have been applied in the empirical literature. These are

(1) The before-after approach, which compares the behavior of key macro-economic variables before and during, or after, any particular reform period, or policy package.

(2) The with-without approach compares the performance of macro-economic variables of non-program countries (the control group) with those from program countries. A modified version of this approach is a reduced form regression estimate that controls for initial conditions in program and non-program countries.

(3) The comparison-of-simulations approach. This approach simulates performance of Fund/Bank-type

programs then compares them with simulated outcomes from another set of policies.

Approaches (2) and (3) have been used extensively in cross-country studies to assess the impact of Fund/Bank-supported programs. The before-after approach has been the most prevalent in country case studies using time series data.

3.1.1 Before-After Approach

The before-after approach has been the most popular in the literature on Fund/Bank-support programs. Reichmann and Stillson (1978) were the first to use this approach in an examination of 79 Fund/Bank-supported programs over the period 1963-1972. They compared growth, balance of payments and inflation in the two years prior to and after the implementation of the program. Connors (1979) also used the before-after approach to evaluate 31 programs in 23 countries over the period 1973-1977. More recent studies include Singh (1995) and the papers in Le Franc (1994), on Jamaica. Similar studies on other developing countries include most of the papers in Tshibaka (1998), Campbell and Stein (1991), La Guerre (1994), Valdés and Muir-Leresche (1993), Commander (1989) and Weeks (1995).

The before-after approach is viewed by some analysts as providing a relatively poor estimate of the counter-factual to program effects by assuming that non-program

determinants of economic variables remain constant between non-program and program periods. This assumption has been questioned in the literature in light of the fact that non-program determinants of economic outcomes (e.g., terms of trade variations, changes in international interest rates, weather, etc.) typically change year after year. Consequently, Goldstein and Montiel (1986) have demonstrated that the before-after estimates of program effects are biased, since all economic changes in program period are incorrectly attributed to program factors. These authors suggested further that the before-after estimates are unsystematic over time, since in any particular year program effects will often be dominated by non-program factors. For example, if a hurricane damages infrastructural works and agricultural crops, then agricultural growth may decline, causing all programs in that year to appear to have performed poorly.

3.1.2 With-Without Approach

The with-without approach seeks to overcome the shortcomings of the before-after approach by comparing economic outcomes between program and non-program countries. Since both groups of countries are subjected to the similar external environments, it is argued that this comparison cancels out the non-program determinants, so

that any observable differences in outcomes in the two groups of countries are attributable to the Fund/Bank-supported programs. In other words, the economic outcomes observed in non-program countries are taken as the counterfactual of what would have occurred in program countries in the absence of Fund/Bank-supported programs.

Donovan (1981, 1982) was the first to use this approach on a sample of Fund/Bank-supported programs implemented between 1970-1980. Loxley (1984) also applied this approach to 38 less developed economies (income of \$690 or less) with Fund/Bank program during 1971-1982. Other similar studies include Gylfason (1987) and Pastor (1987).

A major problem with the with-without approach is that countries in the sample of non-program and program countries are not randomly selected. They are program countries because of poor economic conditions prior to entering into a Fund/Bank-support program. Consequently there is a systematic difference between these two groups of countries and the non-random selection of program countries produces a biased estimate of program effects. This is the result of attributing observable differences in economic outcomes between program and non-program countries to program status, when in fact the initial economic

position of the two groups of countries is an important determinant of economic performance.

To overcome this problem requires identifying the specific differences between program and non-program countries in the pre-program period and controlling for these differences prior to comparing economic outcomes. This is the idea underlying a modified version of the with-without approach. In this regard, Goldstein and Montiel (1986) proposed a generalized evaluation estimator to control for pre-program differences between program and non-program countries. This estimator is a reduced-form relationship that links changes in macroeconomic outcome (program target variables) to lagged values of the target variables, lagged values of policy variables and variables that represent exogenous effects on the target variables. These authors applied this approach to a sample of 58 developing countries in which 68 programs were implemented over the period 1974-1981. The approach was extended by Serieux (1999) to include the effect of democratization in Fund/Bank-supported program countries.

3.1.3 Comparison of Simulations Approach

Finally, the simulation approach relies on simulations of economic models to make inferences on hypothetical outcomes of Fund/Bank-type policy packages. Khan and Knight

(1981), created a simulation using panel data for 29 developing countries in a dynamic econometric model. The objective was to investigate the hypothetical effects of pursuing a stabilization program with similar policy characteristics as a Fund/Bank-supported one. The authors later (Khan and Knight, 1985) extended their simulation exercise to include comparisons of alternative packages. More recent studies include Robinson and Gehlhar (1996), and Chadha et al. (1998), who use computable general equilibrium (CGE) models for the Egyptian and Indian experiences with recent economic reforms, respectively.

3.2 Preliminary Issues in Modeling Supply Response in Jamaica

A number of empirical studies have been conducted in the past to estimate crop supply response in Jamaica. A partial list of these studies is shown in Table 3.1. With the exception of Gafar (1997), all of the studies were conducted prior to the period 1980-1999. In addition, none of the studies addressed the issue of the impact of economic reforms on agricultural supply response.

One approach to capturing the long-run and short-run changes in agriculture supply response is to use the Nerlovian-type partial adjustment models. Both quantity and prices can be modeled to adjust to their long-run or equilibrium path, and the model is capable of estimating

Table 3.1: Empirical Studies on Agriculture Supply Responses in Jamaica.

Crop/ Category	Period	Author & Year	Funct. Form	Price Elasticity Short-run	Price Elasticity Long-run
Banana	1954-1972 1961-1979	Gafar (1980) Pollard & Graham (1985)	Linear log	0.16 0.49	0.57 -2.72
Cocoa	1954-1972 1961-1979	Gafar (1980) Pollard & Graham (1985)	Linear Log	0.41 0.74	2.56 0.76
Coffee	1953-1968 1954-1972 1961-1979	Williams (1972) Gafar (1980) Pollard & Graham (1985)	Log Linear Log	0.70 0.92 0.10	-0.80 1.15 0.07
Citrus	1961-1979	Pollard & Graham (1985)	Log	0.24	-1.33
Sugar	1954-1972 1961-1979	Gafar (1980) Pollard & Graham (1985)	Linear log	0.17-0.29 0.24	0.31-0.7 1.41
Broad Agri. Aggregates	1964-1990	Gafar (1997)	log		
Export				0.20	0.35
Domestic				0.15	1.08
Livestock				0.15	0.21
Forestry & Fishing				0.02	0.21
Total Agri.				0.12	0.23

Source: Adapted from Gafar (1997, p.213).

both long-run and short-run parameters as well as the speed of adjustment towards the long run equilibrium. A potential complication in such an analysis of long-run and short-run changes is that most economic time series data are non-stationary and usually characterized by a unit root.

This means that the linear properties of the series such as its mean and variance, are not constant over the sample but change over time (Greene, 1993; Gujarati, 1995). Nelson and Plosser (1982) have shown that the economic implications of an economic time series that is

characterized by a unit root are different from those of a stationary process. In particular, an economic time series with a unit root will have a permanent response consequent upon any shock in the system. In contrast, a stationary series will reflect only a transitory response. Therefore, the response to economic reform policies is not simply a "policy on", "policy off" or one-shot choice. Even if the reforms were temporary, so long as the economic series possesses a unit root, there will be a permanent response.

Non-stationarity of variables poses problems of estimation of functional relationships using conventional econometric methods. In the first place, Fuller (1976) has shown that under non-stationarity the limiting distribution of the asymptotic variance of the parameter estimates is not finitely defined, hence the conventional t and F tests are inappropriate. Secondly, non-stationarity gives rise to spurious correlation among variables (Greene, 1993). In macroeconomic time series it is not unusual to find that a variable is non-stationary in its level[4] but stationary in first differences. In technical terms, if Y_t is non-stationary, but ΔY_t (the first difference) is stationary, then Y_t is integrated of order one, i.e., $Y_t \sim I(1)$. If two

[4] Data that have not been transformed in any way (such as logarithmic transformation, first differences, etc.), are said to be in 'level' form.

series Y_t and X_t are I(1) then a linear combination of them, e.g., $Z_t = Y_t - \alpha X_t$ may also be I(1). However, there may also exist, a value for α that ensures that Z_t is stationary. In such an event, the two series are said to be cointegrated, and the cointegrating vector is denoted $(1, \alpha)$.

It is tempting to conclude that in order to estimate meaningful relationships among non-stationary variables, all that is necessary is to difference the variables until they achieve stationarity and then estimate the relationship. However, Johansen and Juselius (1990) argue that unless the difference operator is also explicitly applied to the error process, such differencing results in loss of information. In this event, resorting only to estimating the relationship in difference form captures only the short-term effects, while the long-term relationship among the variables is left undetected (Nickell, 1985). Finally, differencing the economic series may not be appropriate, such as when economic theory postulates a relationship among variables in levels, not in difference forms.

To overcome these problems, econometricians have developed an approach known as error correction models based on cointegration. Hylleberg and Mizon (1989, p.124) claim that

> …when estimating structural models it is our experience from practical applications that the error correction formulation provides an excellent framework within which, it is possible to apply both the data information and the information obtainable from economic theory.

Error correction modeling requires two conditions

(1) All variables must be integrated to the same order, i.e., $Y_i \sim I(d)$, where d is the number of times Y has to be differenced to achieve stationarity; and,

(2) All variables must be cointegrated of order $(d - b)$, where $b>0$.

The idea underlying cointegration is that one or more linear combinations of non-stationary variables are stationary. That is, cointegration approaches the stationarity issue as linear combinations of economic series, rather than by differencing the series. The implication of this is that if a set of variables is cointegrated then, following the Granger Representation Theorem (Fuller, 1985) a valid error correction representation of the data exists. In effect, then, cointegration is a test of existence of a long-run relationship of variables that are integrated of the same order (Greene, 1993; Gujarati, 1995). However, an important feature of error correction models based on cointegration is that the data in both levels and differences are included, thereby facilitating investigation of both short-run and long-run effects in the data.

3.3 Error Correction Model

The error correction model (ECM) can be derived from a re-parameterization of an Autoregressive Distributed Lagged (ADL) model (Hendry et al., 1984). Alternatively, the ECM can be derived from the dynamic optimizing behavior of economic agents. This latter approach is presented here.

Following Nickell (1985), suppose economic agents optimize their behavior with respect to an inter-temporal quadratic loss function:

$$(3.1) \qquad L = \sum_{s=0}^{\infty} \alpha^s \Big[\theta_1 \left(Y_{t+s} - Y^*_{t+s}\right)^2 + \left(Y_{t+s} - Y_{t+s-1}\right)^2 - 2\theta_2 \left(Y_{t+s} - Y_{t+s-1}\right)\left(Y^*_{t+s} - Y^*_{t+s-1}\right)\Big]$$

where Y^* is the desired or long-run equilibrium value of Y that the economic agent can control to minimize L, conditional on information at time t, and subject to movements in Y^*. The discounting and weighting factors are $\alpha, (0<\alpha<1)$, and θ_i, $i=1,2$, $(\theta_i>0)$, respectively.

Minimizing (3.1) with respect to Y_{t+s} gives a second order difference equation whose solution at time t is:

$$(3.2) \qquad \Delta Y_t = \theta_2 \Delta Y^*_t + \left(1 - \mu_1\right) \left[\left(\theta_2 Y^*_{t-1} + \left(1 - \alpha\mu_1\right)\left(1 - \theta_2\right)\sum_{s=0}^{\infty} \left(\alpha\mu_1\right)^s Y^*_{t+s}\right) - Y_{t-1}\right]$$

where μ_1 is the stable root (i.e., the root that is < 1) from solving the characteristic equation of the general Euler equation which was derived from minimizing (3.1).

Equation (3.2) is an optimal rule and has an error correction term in brackets [.]; the coefficient $(1-\mu_1)$ is the speed of adjustment, i.e., the speed of closure to any discrepancy between desired and actual values of Y. In the error correction term in (3.2) the long-run target is a convex combination of all target values from Y^*_{t-1} onwards.

Nickell (1985) has shown that when $\theta_2 = 0$ in the loss function (3.1) then equation (3.2) nests the forward-looking partial adjustment model (PAM):

$$(3.3) \qquad \Delta Y_t = (1 - \mu_1)\left[\left\{(1 - \alpha\mu_1)\sum_{s=0}^{\infty}(\alpha\mu_1)^s Y^*_{t+s}\right\} - Y_{t-1}\right]$$

It is important to note that the dynamic equation (3.3) does not necessarily have to be of a standard PAM type. To estimate (3.3) empirically requires the parameterization of Y^*_{t+s}. One way is to model this sequence of expected target values as a stochastic process such that Y^*_{t+s} are expressed in terms of current and lagged values and substituted into (3.3). The resulting equation may not necessarily result in a PAM. Indeed, Nickell demonstrates that when

> ...we allow the target $[Y^*_{t+s}]$ to follow anything more complex than a first order autoregression, the structural equation [3.3], which is fundamentally a partial adjustment model, will reduce to an error correction mechanism in terms of observable variables (Nickell, 1985, p.124).

Suppose that the actual values of the series follow a second order autoregressive scheme with a unit root and a drift:

$$(3.4) \qquad Y_{t+s} = g + \beta Y_{t+s-1} + (1 - \beta)Y_{t+s-2} + \varepsilon_{t+s}$$

where s>0, ε_{t+s} is white noise, and g is the drift. Denoting the expected value with an (*), the expectation of (3.4) is:

$$(3.5) \qquad Y^*_{t+s} = g + \beta Y^*_{t+s-1} + (1 - \beta)Y^*_{t+s-2}$$

Following the derivations by Nickell (1985) and Alogoskoufis and Smith (1991) the solution to the second-order difference equation (3.5) is:

$$(3.6) \qquad Y^*_{t+s} = \frac{Y^*_{t-s+1}}{2 - \beta} gs + \left(1 - (\beta - 1)_{s+1}\right)\Delta Y^*_t$$

Substituting (3.6) into (3.2) yields the decision rule in the form:

$$(3.7) \qquad \Delta Y_t = c + \frac{\theta_2 + (1 - \mu_1)(1 - \theta_2)}{(1 + \alpha\mu_1(1 - \beta))} \Delta Y^*_t + (1 - \mu_1)(Y^*_{t-1} - Y_{t-1})$$

where $c = \dfrac{g(1 - \beta)(2 - \beta\alpha\mu_1)(1 - \mu_1)(1 - \theta_2)}{(2 - \beta)^2[1 + \alpha\mu_1(1 - \beta)]} - \dfrac{g(\alpha\mu_1)(1 - \mu_1)}{(2 - \beta)(1 - \alpha\mu_1)}$

Equation (3.7) is written in the form of an ECM. The parameterization of Y^* in terms of exogenous variables would

reflect the long-run cointegrating relationship. According to Nickell (1985, p.124),

> since it is almost a stylized fact that aggregate quantity variables in economics follow second order autoregression with a root close to unity, we may find the error correction mechanism appearing in many different contexts.

3.4 An Error Correction Model for Crop Supply Response in Jamaica

The dynamically unrestricted version of the ECM in (3.7) can be expressed as:

(3.8) $$\Delta Q_t = \psi_0 + \psi_1 \Delta Q_t^* + \psi_2 \left(Q_{t-1}^* - Q_{t-1}\right)$$

where Q_t is output in logarithm and ψ_0, ψ_1, ψ_2 are straight-forward analogues of the intercept and coefficients in (3.7). Generally, Q_t^* is parameterized in terms of other (weakly) exogenous variables. This parameterization shows the long-run cointegrating relationship between the exogenous variables and the dependent variable, Q_t. Given the unrestricted nature of (3.8) a wide range of possible processes that describe the law of motion of Q_t can be accommodated. Following previous agricultural supply response models, quantity supplied is postulated as a function of the expected values of a set of variables that are believed to capture agricultural incentives. These exogenous variables are, the price of the crop, P_c, the price of substitute crops, P_{si}, i=1,2… and the prices of

inputs. In this study, two inputs are considered, fertilizer and labor, whose prices are denoted as F and W, respectively. With these specifications of the exogenous variables, the parameterization of the long-run equilibrium supply function of the c^{th} crop is:

$$(3.9) \qquad Q^{*}_{c,t} = \beta_0 + \beta_1 P^{e}_{c,t} + \beta_{2i} P^{e}_{si,t} + \beta_3 W^{e}_{t} + \beta_4 F^{e}_{t} + \varepsilon_t$$

$$c = 1 \ldots n;\ i=1,2,\ldots;\ t=1 \ldots T;\ \varepsilon_t \sim iid(0,\sigma).$$

where all variables are measured in logarithms (to facilitate interpretation of estimated coefficients), and have been previously defined. The superscript e denotes expected value of the variables. Given the parameterization in 3.9, the general error correction model, with all variables as previously defined, can be written as:

$$(3.10) \qquad \Delta Q_t = \lambda_0 + \lambda_1 \Delta Q_{t-1} + \lambda_2 \Delta P^{e}_{c,t-1} + \lambda_{3i} \Delta P^{e}_{si,t} + \lambda_4 \Delta W^{e}_{t-1} + \lambda_5 \Delta F^{e}_{t-1} + \lambda_6 \left(Q^{*}_{t-1} - Q_{t-1}\right) + \nu$$

To give empirical content to these models, the specification of expected values must be addressed. Clearly if economic agents had full information about the current variables at the time they are set, then actual values of the variables would be substituted for their expected values. When this is not the case, some process of expectations formation has to be assumed. The applied literature on ECM has largely ignored issues of

expectations. Because of its simplicity in practice, actual values are usually substituted for expected values. An alternative to this procedure is to assume that crop and input prices are determined by policy changes for one year in advance. With this assumption, expectations about current economic variables have to be based on information that is available up to the end of the previous period, $(t-1)$. This can be expressed as:

$$(3.11) \qquad X_t^{re} = E(X_t|\Phi_{t-1}) = E_{t-1}(X_t)$$

where X_t denotes the economic variable of interest, and Φ is the information set available to the economic agent.

Previous studies of crop supply response in Jamaica assumed naïve expectation, based on past (simple) lagged or polynomial lagged prices. Under rational expectations, expected current and future prices of crops, wages and inputs will reflect the generation process for these explanatory-forcing variables. As noted previously, a second order auto-regressive process with a unit root with drift seems adequate to describe the process followed by many economic series. The data on quantities, prices and inputs for this study have been analyzed and found to follow this process. Consequently, the expected prices of crops and inputs are characterized as follows:

$$(3.12) \qquad P_{c,t-1}^{re} = a_0 + a_1 P_{c,t-1} + (1-a_1) P_{c,t-2}$$

(3.13) $$P^{re}_{si,t} = b_0 + b_1 P_{si,t-1} + (1 - b_1) P_{si,t-2}$$

(3.14) $$F^{re}_{t} = c_0 + c_1 F_{t-1} + (1 - c_1) F_{t-2}$$

(3.15) $$W^{e}_{t} = d_0 + d_1 W_{t-1} + (1 - d_1) W_{t-2}$$

Using (3.8)-(3.15), the general error correction model for the c^{th} crop is:

(3.16) $$\Delta Q_{c,t} = \alpha_{0c} + \alpha_{1c,t}\Delta Q_{c,t-1} + \sum_{j=1}^{2} \alpha_{2j}\Delta P_{c,t-j} + \sum_{k=1}^{2} \alpha_{3i,k}\Delta P_{si,t-k}$$
$$+ \sum_{l=1}^{2} \alpha_{4l}\Delta W_{t-l} + \sum_{m=1}^{2} \alpha_{5m}\Delta F_{t-m} + \alpha_6 (Q_c - \delta_1 P_c - \delta_{2i} P_{si}$$
$$- \delta_3 W_t - \delta_4 F_t)_{t-1};$$

where, i=1,2, all variables as previously defined, and the random error term is suppressed.

The last term in (3.16) is the error correction term. In the empirical estimation of the ECM (3.16), the error correction term is usually specified as the residual from the cointegrating relationship.

The Engle-Granger (1987) two-step method has been used extensively in the applied literature to estimate the ECM (3.16). However this method assumes that the cointegration vector is unique. Except in the bivariate model, this assumption may be violated in multivariate models. To test for, and estimate multiple cointegrating vectors, Johansen (1988) and Johansen and Juselius (1990) have devised an appropriate method within the following framework. Define a

standard vector autoregressive (VAR) model with lag length k as:

$$X_t = \Pi_1 X_{t-1} + \Pi_2 X_{t-2} + \ldots + \Pi_k X_{t-k} + \varepsilon_t \qquad (3.17)$$

$$t=1\ldots,T$$

where X is an Nx1 vector of N endogenous variables, $\varepsilon_t \sim iid$ $(0,\Lambda)$ with dimension NxN. The long-run, or cointegrating matrix is:

$$I - \Pi_1 - \Pi_2 - \ldots - \Pi_k = \Pi \qquad (3.18)$$

The number of distinct cointegrating vectors, r, which exists between the variables of X, is given by Rank (Π).

Most economic time series appear to be integrated to the order of one, in which case, $r \leq N-1$, where N is the number of variables in the vector X. In the case of a bivariate model, $N=2$, and therefore if the variables are cointegrated, then there is a unique cointegrating vector.

The matrix Π is then decomposed as:

$$\Pi = \alpha\beta' \qquad (3.19)$$

where β represents the matrix containing the r cointegrating vector, and α is the matrix of weights with which each cointegrating vector enters each of the differenced X equations. A large α value implies that the system will respond to any deviation from the long-run equilibrium path with a rapid adjustment. If α's are zero

in some equations, this is a sign of a weak exogeneity, implying that the variable does not respond to the disequilibrium in the system. The parameters α and β form an over-parameterization of the model. However, the space spanned by β, sp(β), can be estimated, and shown to be the empirical canonical variates of X_{t-k} with respect to ΔX_t. This is in effect the following theorem advanced by Johansen:

> The maximum likelihood estimator of the space spanned by β is the space spanned by the r canonical variates corresponding to the r largest squared canonical correlations between the residuals of X_{t-k} and ΔX_t corrected for the effect of the lagged differences of the X process. (Johansen, 1988, p.233)

Implementation of this theorem begins by re-parameterizing (3.17) (detailed derivations are in Johansen, (1988) and Enders, (1995)), into the following error correction model:

$$\Delta X_t = \Gamma_1 \Delta X_{t-1} + \ldots + \Gamma_{k-1} \Delta X_{t-k+1} + \Gamma_k X_{t-k} + \varepsilon_t \qquad (3.20)$$

where $\Gamma_i = -I + \Pi_1 + \Pi_2 + \ldots + \Pi_i$, $i=1 \ldots k$

Without any loss of information, the ECM in (3.20) is therefore a transformation of the VAR(k) model in equation (3.17), and is expressed in first differences and augmented by the error correction term, $\Gamma_k X_{t-k}$. The long-run equilibrium or impact matrix is the matrix Γ_k and is equivalent to $\Pi = \alpha'\beta$ in (3.19). The rank of Π is the basis of

determining the number of cointegrating relationship between the variables in the ECM (3.20). Johansen (1988) identifies three possibilities with regards to Rank(Π),

(1) rank(Π) = 0. This means that the variables are not cointegrated and the model is basically a VAR in first differences.

(2) 0 < Rank(Π) < p. In this case, the variables are cointegrated and the number of cointegrating relationship(s) is less than the number of variables, p, in the model.

(3) rank(Π) = p. This means that all variables are stationary and the model is in effect a VAR in levels.

The loglikelihood representation of (3.20) is:

(3.21) $$L(\alpha, \beta, \Omega) = |\Omega|^{-T/2} \exp\left[-\frac{1}{2}\sum_{t=1}^{T}\left(R_{0t} + \alpha\beta' R_{kt}\right)' \Omega^{-1}\left(R_{0t} + \alpha\beta' R_{kt}\right)\right]$$

Johansen's procedure begins by regressing ΔX_t on the lagged differences of ΔX_t and generating fitted residuals R_{0t}, then regressing X_{t-k} on the lagged differences and generating fitted residuals, R_{kt}. These fitted residuals are then used to construct the following product moment matrices:

(3.22) $$S_{ij} = \frac{1}{T\sum_{i=1}^{T} R_{it}} R_{jt}, \quad i, j = 0, k$$

The product moment matrices (3.22) are then used to find the cointegrating vectors by solving the determinant:

$$(3.23) \qquad \left|\lambda S_{kk} - S_{k0}S_{00}^{-1}S_{0k}\right| = 0$$

This will yield the estimated eigenvalues (λ_1, …, λ_n) and eigenvectors (v_1,…,v_n), which are normalized such that:

$$(3.24) \qquad V'S_{kk}V = I$$

where V is the matrix of eigenvectors. The most significant eigenvectors then constitute the r cointegrating vectors, i.e.,

$$(3.25) \qquad \beta = (v_1, \ldots v_r)$$

Using (3.25), α is then estimated from (3.19).

The critical issue in all of this is to determine which, and how many, of the eigenvectors in (3.24) represent significant cointegrating relationships. First, the β vectors that have the largest partial correlation with ΔX_t, conditional on the lags of ΔX_t, are identified. Second, the eigen vectors that correspond to the r largest eigen values are chosen. Finally, to determine the value of r the following test statistics suggested by Johansen (1988) are employed:

$$(3.26) \qquad \Omega_1(q, n) = -T\sum_{i=q+1}^{n} \ln(1 - \lambda_i)$$

$$(3.27) \qquad \Omega_2(q, q + 1) = -T\ln(1 - \lambda_{q+1})$$

The null hypothesis H0: $r \leq q$ is tested with (3.26), while H0: r = q is tested against H1: r = q + 1 with (3.27). The critical values for these tests are taken from Osterwald-Lenum (1992). The critical values from this source recalculates and extends those critical values from Johansen (1988) and Johansen and Juselius (1990), to handle a full test sequence from full rank (r = p, i.e., X_t is stationary) to zero rank (r = 0, i.e., all linear combinations of X are I(1)), for at most 11-dimensional systems.

The cointegration technique is used to determine the long-run relationships among variables. This co-movement of variables in a long-run supply function has not been explored for Jamaica. Cointegration analysis is appropriate in this regard. It will also suggest which variables in the supply function are in the long-run equilibrium.

3.5 The Data

The principal sources of annual time series data, which are used in this study, are the Food and Agriculture Organization (FAO) agricultural database (FAOSTAT), available on the internet, and annual publications of various government agencies in Jamaica. These include, Economic and Social Survey of Jamaica (Jamaica, Planning Institute of Jamaica); Production Statistics (Jamaica, Statistical

Institute of Jamaica (STATIN)); Statistical Digest (Jamaica, Bank of Jamaica), Statistical Year Book of Jamaica (Jamaica, Statistical Institute of Jamaica (STATIN)); Census of Agriculture, 1968, 1978, 1996 (Jamaica, Statistical Institute of Jamaica (STATIN)); International Financial Statistics (IMF); and data from published and unpublished documents from the Ministry of Agriculture in Jamaica.

It should be noted that the data on Jamaica contained in the FAO database, FAOSTAT, IMF and World Bank sources are based on publications and data supplied by STATIN, Ministry of Agriculture, and other agencies of the Government of Jamaica. The data used to estimate the supply functions in this study are taken from the FAO FAOSTAT database. This is the most comprehensive data set on crop output and prices in Jamaica. However, in several areas the data are less than ideal. For example, whenever data are not available the FAO provides its own estimates based on past crop performance, other crops and other country's data. Jamaican officials claim that production data for some crops reported on the FAO data base are not monitored in Jamaica.

The crop output and price data are annual series, and are collected at the farmgate through periodic production

surveys and agricultural censuses. Farmers in the Caribbean rarely keep records of production, cost expenditures and so on. Hence, for these farmers it is difficult to recall data for production surveys that are conducted between long periods. Consequently, this casts some amount of suspicion on the reliability of the data. Nonetheless, these are the data reported as official statistics, and are used by the government as a basis for policy analysis/discussion.

Several important economic aggregates were not adequately covered in the data sources. In particular, data on agricultural wages are not available on Jamaica. As a result, a proxy for this variable was constructed from data on compensation to agricultural employees recorded in the national accounts. Data on consumer price indexes--the basis for deflating crop and input prices in this study--were not available as continuous series over the 1962-1999 period. Consequently, a combination of splicing indexes and converting the final 1962-1999 series to a 1980 base year was undertaken.

Although the data are less than ideal in several areas, and are bound to contain some noise, the advantages of using them are:

(1) they are from a common source and are characterized by a common accounting/estimating procedure in their derivation; and

(2) the data are the most comprehensive time series available on Jamaican crop supply in a single source.

3.6 Summary

There are competing approaches in the literature on how to evaluate the impacts of economic reforms associated with Fund/Bank-type policy packages. Each approach utilizes the idea of a counterfactual against which actual economic outcomes in the program period are compared. Estimating crop supply responses over a period in which significant policy changes have occurred, requires a modeling framework that is capable of capturing both the long-run and short-run changes. The Nerlovian-type supply response models have been used in the literature for this purpose. However, in the context of data series that are non-stationary, this approach can produce spurious regressions. A more appropriate analytical framework is that provided by error correction models based on cointegration analysis.

CHAPTER 4
EMPIRICAL ESTIMATION OF CROP SUPPLY RESPONSE

The aim of this chapter is four-fold. First, the central motivations for using error correction modeling based on cointegration theory in this study are presented. Second, the time-series data on prices and quantities to be used in the ECMs to estimate crop supply responses in Jamaica are tested for stationarity. Third, long-run supply responses are estimated for eight agricultural crops. Finally, the short-run dynamics of the crop supply responses are analyzed.

4.1 Motivations for Using Cointegration Analysis

Chapter 3 provides a fairly elaborate treatment of the theoretical and statistical aspects of error correction modeling based on cointegration theory. Against that background, it is useful to recall in a cryptic, condensed and fairly non-technical way, the central motivations for using this approach to address the issues with which this study is concerned.

The empirical purpose of this study is to investigate the impact of economic reforms on crop supply responses in

Jamaica. Generally, supply response models in agriculture postulate a long-run relationship between output and agricultural incentives (Askari and Cummings, 1976). Deviations from this long-run equilibrium occur in the short-run and may involve considerable adjustment costs to the economic agent. This is especially the case when significant policy changes are implemented. Jamaica provides a good case for evaluating the connections between economic reforms and supply responses. The country has traditionally been heavily dependent upon agriculture for food, employment and export earnings. A combination of excesses in state intervention and adverse world economic conditions prompted major economic reforms in the late 1970s in the form of serious macroeconomic stabilization policies under the direction of the IMF.

During the early 1980s more far-ranging structural reforms were instituted in an effort to reverse the current account and fiscal deficits, reduce inflation and monetary growth to achieve financial stability, restore economic growth, and so on. Implicitly in these early reforms, but more explicitly in the late 1980s and throughout the 1990s, the aim has been to re-orient the economy towards a more liberal economic system. These reforms took expression in progressive devaluation of the Jamaican dollar, elimination

of state marketing boards, liberalization of agricultural input and output prices and privatization of state held monopolies and public enterprises. Intuitively, therefore, the analysis of supply responses in these situations would require a modeling framework that is capable of incorporating both the long-run and short-run changes.

A preliminary analysis of the Jamaican crop output and price data series over the 1962-1999 period reveals substantial fluctuations, especially since the early 1980s. The strongly time trended data imply a statistical problem that has not been addressed in applied analysis on Jamaican crop supply responses. This statistical problem is referred to, in the literature, as non-stationarity of the time series.

The analytical approach chosen in this study to deal with the above mentioned issues, emphases the importance of considering the interactions between the variables in the system in a simultaneous equation model, and to distinguish between the short-run and long-run effects. The modeling approach differs from those previously used to model Jamaican crop supply responses in two very important ways. First, the data are analyzed as a full system of equations. This allows for possible interactions in determining the precise relationships among the variables in the system.

Second, the multivariate cointegration modeling which is used in this study, is designed for this type of empirical work by explicitly classifying the non-stationary and stationary components and facilitating an interpretation in terms of the dynamics of short-run and long-run effects. There are two general motivations for using error correction models based on cointegration theory in applied economic analyses. First, when time-series data are non-stationary, i.e., their linear properties, such as mean and variance, are time dependent, then conventional econometric analysis on such data may produce "spurious" results.

Second, even though a set of time series may individually be non-stationary, there may be a linear combination among them that is stationary. Such series are said to be cointegrated, that is, they have a tendency to move together in the long-run, even though in the short-run they may diverge from each other. This co-movement of related series suggests the existence of long-run relationship between them. So when data are non-stationary there is the additional possibility that the data generating process contains information about the equilibrium process that makes the process adjust toward the long-run steady state or the equilibrium path.

There is, therefore, additional economic insights gained from the recognition that the data are non-stationary. The component $\Gamma_k X_{t-1}$, ($\equiv \alpha\beta' X_{t-1}$, since $\Pi = \alpha\beta'$), in equation (3.20), is directly related to the non-stationarity in the data. Since this component contains information about the speed of adjustment, α, to some long-run relations, $\beta' X_t$, and if the data are cointegrated, then the economic process can generally be understood within a theoretical model that assumes some adjustment behavior. This means that theoretical models such as the partial adjustment model (PAM), which assume static equilibrium, cannot be used when data are non-stationary.

4.2 Definition of Variables

In this chapter, error correction models based on cointegration theory are used to test the hypothesis that long-run relationships exist between crop output and price incentives in Jamaica. The estimation procedure is based on the work of Johansen (1988) and Johansen and Juselius (1990). There are basically three steps in this estimation procedure

(1) test the order of integration of the variables and specify the lag length of the variables using a standard vector auto-regressive (VAR) specification.

(2) estimate the ECM and the number of cointegrating relationship(s) among the variables included in the ECM.

(3) perform short-run analysis by conducting innovation accounting on the ECM.

For each crop a p-variable vector autoregression (VAR) of lag k is specified. The model is re-parameterized into an error correction model (ECM) as specified in equation (3.20) and estimated according to the methodology of Johansen (1988) and Johansen and Juselius (1990). Estimation is done using the Regression Analysis for Time Series (RATS), version 4.3 (Doan, 1996), and Cointegration Analysis for Time Series (CATS) in RATS, (Hansen and Juselius, 1995), computer programs. The variables in each ECM include the output (quantity) of the crop of interest, the price of the crop, the price of a substitute (or alternative) crop, and two input prices, average agricultural wage rate and average fertilizer price.

The choice of a crop price variable is critical for the estimation of crop supply responses. In this regard, Askari and Cummings (1976) suggest using any one of the following prices:

(1) Nominal farmgate price;

(2) Farmgate price deflated by any one of the following:

(a) a price index of farmer's inputs;

(b) a consumer price index; and

(c) some index of the prices of competitive crops (or the price of the most competitive crop).

An additional issue that is related to the choice of an appropriate price variable for the crop supply functions especially within the context of the IMF/World Bank programs in Jamaica, is that agricultural price incentives are influenced by various macroeconomic policies. Of particular importance, in this regard, is the real exchange rate (RER), defined as the ratio of prices of tradable (P_T) to non-tradable (P_N) goods (Tsakok, 1990). Krueger (1992) and Schiff and Valdés (1992a, 1992b), have shown extensively how macroeconomic policies in developing countries generally have a RER effect, which ultimately affect output price and agricultural supply. In the empirical literature the RER is usually approximated as RER=e*WPI/CPI, where WPI is the foreign wholesale price index, CPI is the domestic consumer price index, and e is the official exchange rate. The World Bank's approach to showing the link between macroeconomic policies (as represented by the RER) and real crop prices, decomposes real producer price as follows:

$$RPP = P_F/CPI = P_F/P_Be = e(WPI/CPI) = NPC*RER*p_B$$

where RPP is real producer price, P_F is the farmgate producer price, P_B is the border price, NPC is the nominal protection coefficient, and p_B is the real border price of the country's exports (World Bank, 1994). This definition of RPP shows that it contains information on the RER and also reveals that it is really hazardous to include both the RER and RPP in the same equation (Mamingi, 1997).

In addition to the issues raised above, two additional considerations were taken into account in the choice of the crop price variable. First, since farm producers sell most of their marketable surplus immediately after reaping, farmgate prices seem to be a good approximation for prices received. Second, since farmers purchase most of their requirements from retail markets, the consumer price index seems to be an appropriate deflator for producer prices. For these reasons, therefore, the farmgate price deflated by the CPI was used as the real producer price (RPP) variable in the supply functions. In effect, this price variable reflects not only price incentives to the producers, but also macroeconomic (reform) policies (as represented by the RER). In particular, this link between the price variable and macroeconomic policies is important in order to pursue an investigation of the hypotheses advanced on page 11.

The question regarding which alternative (or substitute) crop to include in a particular crop's ECM proved to be difficult. In the absence of recorded data on this issue, the final choice of the substitute crop resulted from a consideration of a number of factors. Among these were, the nature of the crops (traditional export versus domestic crops); the terrain where the crops are grown (mountainous versus flat lands); tree-crops versus annuals; and, root-crops versus vine-crops. The difficulty of identifying an appropriate substitute crop (or crops) can be demonstrated in the case of banana. Possible substitute crops for banana are coffee and sugar, since these are all traditional export crops. Banana is grown extensively on flat lands, but is also cultivated on hilly terrains as is coffee, whereas, sugar growing has been confined to the relatively flat plains in Jamaica. Hence, both sugar and coffee are plausible substitutes for banana, and the choice of either one or both becomes an empirical issue.

A further complication in the choice of a substitute crop arises. In the early 1990s, this researcher observed two cases where lands which were previously used to cultivate sugar and banana were converted into papaya groves. Telephone interviews conducted with officials of

the Ministry of Agriculture, Government of Jamaica, indicate that these are not isolated cases, and that similar land conversions have been observed into cut-flowers, decorative foliage, aloe-vera, ochro, and other non-traditional export crops.

Several substitute crops were initially included in each ECM but in all cases it was found that the inclusion of only one substitute crop price improved the statistical properties of the model. The alternative crops in each crop's ECM are reported in Table 4.1.

Table 4.1: Alternative (Substitute) Crops in Each ECM.

Crop	Alternative Crops Considered
Banana	Sugar*, coffee, papaya
Sugar	Banana*, papaya
Coffee	Banana*, pimento, sugar, orange
Pimento	Banana*, coffee, cocoa bean
Yam	Cassava*, potato, sweet potato
Orange	Grapefruit*, tangerine, coffee
Cocoa Bean	Banana*, pimento, coffee
Potato	Cassava*, yam, sweet potato

* Crop chosen as substitute crop.

Two input prices are included in each crop's ECM, namely, fertilizer price and average wage in the agriculture sector. The fertilizer price variable is a weighted price index of all types of fertilizers imported into Jamaica, with quantities as weights. With respect to the wage variable, there are no data on agriculture wages

in Jamaica. A proxy for this variable was constructed from data on compensation to agricultural employees recorded in the national income accounts. Compensation of agricultural employees is

> defined to include all payments by … producers of wages and salaries to their employees in kind and in cash, and of contributions paid or imputed, in respect of their employees to social security schemes and to private pensions, family allowance, casualty insurance, life insurance and similar schemes. (Jamaica, National Income and Product, 1970, p.50)

Total compensation to agricultural workers is divided by total agricultural labor force to yield a proxy for the average nominal wage rate. The latter is then divided by the consumer price index and used as the proxy for average real wage rate in the agricultural sector.

All variables are measured in logarithms and indexed at 1980=100. The logarithmic transformation of the data was done because of ease of interpretation of the estimated coefficients and the frequency of its use in the econometric literature. In addition, Doan (1996) has argued that preliminary data transformation helps to straighten out trends and eliminate systematic tendency of the variance of the series to depend on the magnitude of the data. To save on degrees of freedom, the smallest lag-length was sought while at the same time seeking to pass the diagnostic tests on the residuals. After some

experimentation and testing, a lag-length of k=2 was settled upon. This is the minimal lag length required for an ECM, and is sufficiently long to accommodate the issues of expectations discussed in Chapter 3.

The residual analysis for adequacy of model specification combines statistical testing and interpretation of graphs. Tests for autocorrelation utilize the Ljung-Box (L-B), LM(1) and LM(4) tests. The (L-B) test is a test of the null hypothesis that the residuals from the first T/4 observations are not autocorrelated. The LM(1) and LM(4) are tests of the null hypotheses of no first- and fourth-order autocorrelation. A multivariate test using the procedure of Doornik and Hansen (1994) is used to test the null hypothesis that the residuals from the system of equations are normally distributed. Finally, the autoregressive conditional heterosckedasticity (ARCH) test is used to test the null hypothesis that the residuals of each equation in the system are normally distributed.

All of the tests mentioned above are distributed as χ^2 with the appropriate degrees of freedom and corrected for small sample bias when necessary. A sample of graphs that aid in the residual analysis is presented in Section 4.4. These residual graphs and residual test statistics for the

tests mentioned above, are normal output from the RATS/CATS program when estimating ECMs, using the Johansen approach.

4.3 Testing for Stationarity

A preliminary step in the estimation of the ECM models is to test the data for stationarity. Three tests are used in this study, the Dickey-Fuller (D-F) and Augmented-Dickey-Fuller (ADF), the Weighted Symmetric (W-S), and the Phillips-Perron (P-P) tests. The Time Series Processor (TSP), (version 4.4), was used to conduct these three tests on all quantity and price data. First, tests were conducted on the variables in levels, then on their first difference. The results are shown in Tables 4.2 and 4.3.

For the Dickey-Fuller test, the following models were used:

$$\Delta X_t = \alpha_0 + \alpha_1 X_{t-1} + \mu_t \tag{4.1}$$

$$\Delta X_t = \alpha_0 + \alpha_1 X_{t-1} + \alpha_2 T + \mu_t \tag{4.2}$$

where T is time, X_t is a time series, α_i are coefficients to be estimated, μ_t is white noise, and ΔX_t the first difference. The ADF tests were conducted on the following equations:

$$\Delta X_t = \alpha_0 + \alpha_1 X_{t-1} + \beta_i \sum_{i=1}^{m} X_{t-i} + \mu_t \tag{4.3}$$

$$\Delta X_t = \alpha_0 + \alpha_1 X_{t-1} + \alpha_2 T + \beta_i \sum_{i=1}^{m} \Delta X_{t-i} + \mu_t \tag{4.4}$$

Table 4.2: Unit Root Tests--Prices and Quantities in Levels.

Variable	Tests for Price			Tests for Quantity		
	W-S[a]	DF[b]	P-P[c]	W-S[a]	DF[b]	P-P[c]
Banana	-2.85 (0.13)	-2.49 (0.34)	-10.22 (0.42)	-1.74 (0.80)	-3.70 (0.02)	-5.39 (0.79)
Sugar	-1.66 (0.83)	-1.24 (0.90)	-4.24 (0.87)	-1.39 (0.92)	-1.14 (0.92)	-5.41 (0.79)
Coffee	-2.91 (0.11)	-2.13 (0.53)	-9.08 (0.50)	-1.08 (0.97)	-3.08 (0.11)	-25.21 (0.02)
Pimento	-2.96 (0.09)	-2.57 (0.29)	-15.83 (0.16)	-2.21 (0.49)	-2.40 (0.38)	-12.44 (0.29)
Yam	-1.96 (0.67)	-1.59 (0.80)	-7.81 (0.60)	-2.06 (0.61)	-4.10 (0.01)	-9.46 (0.47)
Orange	-1.55 (0.88)	-1.34 (0.88)	-4.95 (0.82)	-1.33 (0.93)	-2.43 (0.36)	-10.63 (0.40)
Cocoa Bean	-2.36 (0.38)	-2.07 (0.56)	-7.94 (0.59)	-2.89 (0.12)	-2.53 (0.32)	-20.69 (0.06)
Potato	-2.36 (0.39)	-2.02 (0.59)	10.74 (0.39)	-3.12 (0.06)	-0.58 (0.98)	-20.94 (0.06)
Fertilizer	-1.972 (0.667)	-1.142 (0.922)	-13.460 (0.141)			
Wage	-2.092 (0.135)	0.743 (1.000)	-16.639 (0.120)			

Note: Numbers in parentheses are P-values.
[a] Weighted Symmetric Test.
[b] Dickey-Fuller Test.
[c] Phillips-Perron Test.

The order of the ADF test (i.e., the value of m) was chosen on the basis of residual whiteness, since the ADF test is not valid when serial correlation among the errors exists. The test statistics from equations (4.1)-(4.4) are not distributed as a t-distribution because under Ho: non-stationarity, the variance is not finite. Fuller (1976) has simulated the critical values of the distribution for equations (4.1)-(4.4).

The (W-S) test is sometimes recommended over the (D-F) tests due to its higher power (Pantula et al., 1994). The

Table 4.3: Unit Root Tests--Prices and Quantities in First Difference.

Variable	Tests for Price			Tests for Quantity		
	W-S[a]	DF/ADF[b]	P-P[c]	W-S[a]	DF/ADF[b]	P-P[c]
Banana	-3.80 (0.01)	-2.12 (0.54)	-18.21 (0.10)	-4.81 (0.00)	-3.23 (0.08)	-18.32 (0.10)
Sugar	-3.67 (0.01)	-2.11 (0.54)	-17.33 (0.12)	-3.65 (0.01)	-3.36 (0.06)	-42.73 (0.00)
Coffee	-3.92 (0.01)	-3.61 (0.03)	-29.02 (0.01)	-3.88 (0.01)	-3.65 (0.03)	-43.70 (0.00)
Pimento	-3.25 (0.04)	-3.00 (0.13)	-44.74 (0.00)	-3.66 (0.01)	-3.47 (0.04)	-39.44 (0.00)
Yam	-3.39 (0.03)	-2.97 (0.14)	-24.80 (0.03)	-3.32 (0.03)	-4.05 (0.01)	-24.77 (0.03)
Orange	-2.90 (0.11)	-3.56 (0.03)	-24.54 (0.03)	-4.17 (0.00)	-3.90 (0.01)	-42.52 (0.00)
Cocoa Bean	-3.24 (0.04)	-2.94 (0.15)	-31.13 (0.01)	-3.54 (0.02)	-3.29 (0.07)	-39.41 (0.00)
Potato	-3.99 (0.00)	-3.70 (0.02)	-28.38 (0.01)	-2.47 (0.31)	-3.12 (0.10)	-28.49 (0.01)
Fertilizer	-6.112 (0.063)	-5.180 (0.052)	-42.821 (0.000)			
Wage	-6.472 (0.024)	-6.639 (0.017)	-43.081 (0.000)			

Note: Numbers in parentheses are P-values.

[a] Weighted Symmetric Test.

[b] Dickey-Fuller/Augmented Test.

[c] Phillips-Perron Test.

(W-S) test uses a weighted double-length regression. The first half of the regression regresses Y_t on Y_{t-1} and lags of ΔY_t, with weights (t-1)/T, where T is the full sample size, and t the size of the sub-sample used for the first half of the regression. In the second half of the regression Y_t is regressed on Y_{t+1} and leads of Y_t-Y_{t-1} with weights [1-(t-1)]/T (Hall and Cummins, 1998). Phillips and Perron (1988) have suggested a variant to the Dickey-Fuller test by using a non-parametric General Methods of Moments (GMM) type

method to compute a residual variance which is robust to serial correlation.

The unit root tests indicate that for each variable tested, at least one test shows that the variable is non-stationary in levels, but stationary in first differences. The conflicting test results reported in Table 4.3 derive from the different power of these tests, which in turn depend upon the estimators used (Pantula et al., 1994). This should not pose any serious estimation problem, since Hansen and Juselius (1995, p.1), argue that

> …not all individual variables included in [a multivariate cointegration model] need be I(1), as is often incorrectly assumed. To find cointegration between non-stationary variables, only two of the variables have to be I(1).

Consequently, the estimation of crop supply response which follows is based on the conclusion that the variables included in the models are all integrated of order one, i.e., $Y_i \sim I(1)$, which implies that, $\Delta Y_i \sim I(0)$.

4.4 Estimating Long-run Supply Response

For the banana ECM, the vector of stochastic variables is:

X_t = (lbanq, lbanpr, lsugpr, lwage, lferp)′

where lbanq = quantity of banana; lbanpr = price of banana; sugpr = sugar price (the alternative crop to banana); lwage = average wage in the agricultural sector; lferp = average

price of fertilizer. The 'l' that begins each variable name indicates that the variables are measured in logarithms.

The diagnostic statistics for residual analysis for the unrestricted model for banana are shown in Table 4.4 and suggest that the assumed model for the banana ECM is supported by the data. This is also supported by the graphs in Figures 4.1-4.5, where in particular, the standardized residuals all show a zero-reverting pattern. The next step

Table 4.4: Diagnostic Statistics for Residual Tests for the Banana ECM.

Tests	Df[a]	χ^2	p-value
For normality of residuals	10	10.322	0.21
For autocorrelation			
L-B(9)	124	102.050	0.06
LM(1)	25	23.629	0.54
LM(4)	25	20.661	0.71
For ARCH(2)			
Lbanq	2	1.961	
Lbanpr	2	1.492	
Lsugpr	2	0.575	
Lferp	2	0.638	
Lwage	2	0.913	

Notes: The critical value for $\chi^2(2) = 5.99$ at the 95 percent significance level.
[a] Df = degrees of freedom.

estimates the number of cointegrating relationships, r, in the system.

In Table 4.5 the likelihood ratio test statistics for the rank of Π (from equation 3.19) are presented along with

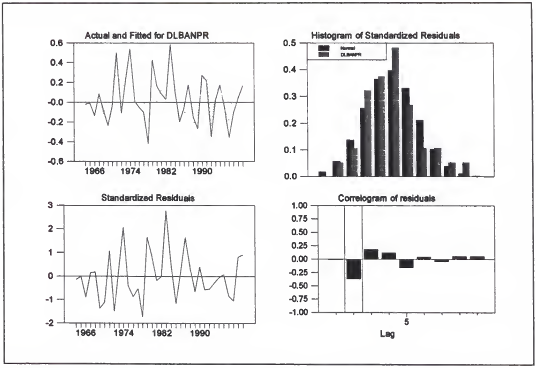

Figure 4.1: Residuals for Banana Price in Banana ECM.

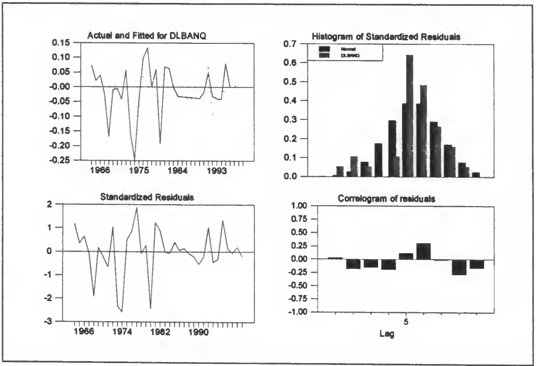

Figure 4.2: Residuals for Banana Quantity in Banana ECM.

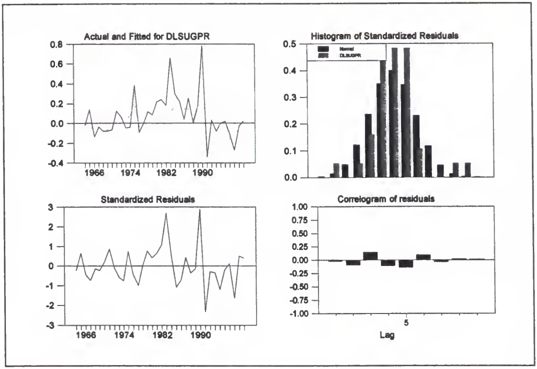

Figure 4.3: Residuals for Sugar Price in Banana ECM.

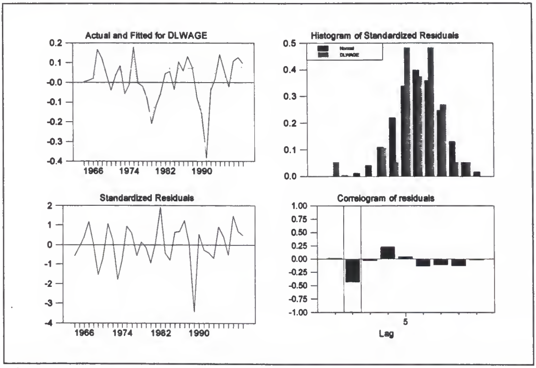

Figure 4.4: Residuals for Wage in Banana ECM.

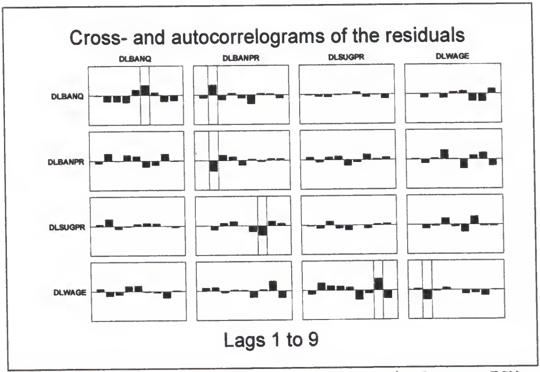

Figure 4.5: Cross- and Autocorrelograms in Banana ECM.

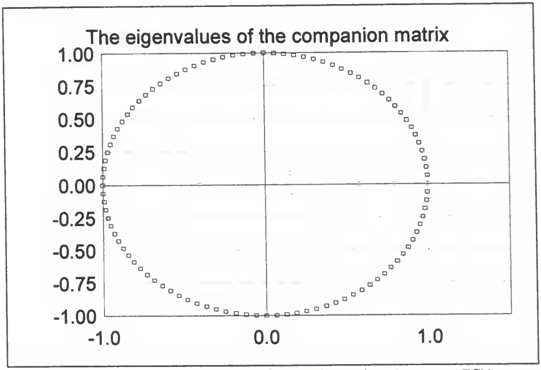

Figure 4.6: Plot of Eigenvalues for the Banana ECM.

Table 4.5: Tests of Cointegration Rank for Banana ECM.

Eigen Values	λmax	Trace	Ho:r	P-r	λmax 90	Trace 90
0.649	37.66	80.99	0	5	21.74	71.66
0.369	16.56	43.33	1	4	18.03	49.92
0.332	14.54	26.27	2	3	14.09	31.88
0.022	8.96	12.23	3	2	10.29	17.79
0.087	3.27	3.27	4	1	7.50	7.50

the 90 percent quantiles of the appropriate limiting distributions. The estimated maximum eigenvalue and trace statistics are shown in the columns λmax and Trace, respectively. The corresponding critical values at the 90 percent level are in the columns λmax 90 and Trace 90. Testing is done sequentially (i.e., row by row), beginning with the first row in Table 4.5, until non-rejection of the null hypothesis is found. This sequential testing begins by testing the null hypothesis Ho:r = 0, (i.e., there is no cointegrating relationship in the system) in row one of Table 4.5. Testing is done by comparing the estimated λmax and Trace statistics with their theoretical (tabular) counterparts, λmax 90 and Trace 90, respectively. The null hypothesis Ho:r = 0 is rejected since the estimated test statistics, (λmax = 37.66 and Trace = 80.99), are greater than the corresponding critical values for these statistics (λmax 90 = 21.74 and Trace 90 = 71.66), respectively. Row

two is then examined. In Table 4.5, Ho:r = 1 cannot be rejected, since the estimated test statistics (λmax = 16.56 and Trace = 43.33) are less than their critical values (λmax 90 = 18.03 and Trace 90 = 49.92), respectively. This suggests that there is one long-run or cointegrating relationship in the banana ECM. This is also supported by the graph in Figure 4.6 which shows that the eigenvalues are all within the unit circle.

The model is then re-estimated under the restriction that only one cointegrating relationship exists in the system. The resulting cointegrating relationship is:

(4.5) -6.158lbanq - 3.943lbanpr + 0.957lsugpr

+ 0.655lwage + 3.464lferp - 23.365 = 0

After normalizing on the banana variable and transferring the banana quantity variable to the left hand side of the equal sign the estimates for the cointegrating vector, β, and the vector of weights, α, are shown in Table 4.6.

Table 4.6: Estimated Long-run and Adjustment Coefficients, β's, α's--Banana ECM.

	lbanq	lbanpr	lsugpr	lwage	lferp	constant
β's	1	0.640	-0.156	-0.567	-0.106	-3.795
α's	-0.141 (-1.909)[c]	-0.352 (-1.949)[c]	0.511 (2.452)[b]	0.169 (3.329)[a]	0.097 (0.641)	

Note: Figures in parentheses are t-values.
[a], [b], [c], indicate statistical significance at one, five and ten percent levels, respectively.

The cointegrating parameters can be interpreted as long-run elasticities. Thus, a ten percent increase in the price of banana will lead to a 6.40 percent increase in banana supply in the long run, other things remaining constant. Similarly, a ten percent increase in the average price of fertilizer will lead to a 1.06 percent decrease in banana supply. With respect to the substitute crop, a ten percent increase in sugar price will lead to a 1.60 percent decrease in banana quantity. Finally, a ten percent increase in agricultural wage rate will lead to a 5.70 percent decrease in banana output.

The coefficients in the α-vector are the weights with which the cointegrating vector(s) enter(s) each of the individual equations in the system. This can be seen from the estimated Π matrix (4.6):

$$(4.6)\qquad \Pi = \alpha\beta' = \begin{bmatrix} -0.141 \\ -0.352 \\ 0.511 \\ 0.097 \\ 0.169 \end{bmatrix} \begin{bmatrix} 1 & 0.640 & -0.156 & -0.567 & -0.106 & -3.795 \end{bmatrix}$$

$$\Pi = \begin{bmatrix} \text{lbanq} \\ \text{lbanpr} \\ \text{lsugpr} \\ \text{lferpr} \\ \text{lwage} \end{bmatrix} = \begin{bmatrix} -0.141 & -0.091 & 0.022 & 0.080 & 0.015 & 0.536 \\ -0.352 & -0.225 & 0.055 & 0.198 & 0.037 & 1.334 \\ 0.511 & 0.327 & -0.079 & -0.287 & -0.054 & -1.938 \\ 0.097 & 0.062 & -0.015 & -0.055 & -0.010 & -0.369 \\ 0.169 & 0.108 & -0.026 & -0.095 & -0.018 & -0.642 \end{bmatrix}$$

In terms of an economic interpretation, these α coefficients can be considered as the average speed of adjustment towards the estimated equilibrium. Thus, a small

coefficient indicates a slow adjustment whereas a large coefficient indicates rapid adjustment. At the indicated levels of statistical significance, all variables in the banana ECM (except fertilizer price) adjust to a deviation from the long-run equilibrium relationship.

In the equation that estimates the long-run supply response of banana (lbanq in equation 4.6), the average speed of adjustment is $\alpha_{lbanq} = -0.141$, implying that about 15 percent of any deviation from the long-run equilibrium in quantity is corrected within the first period. When the speed of adjustment is low, this might be caused by government regulations, high cost of adjustment, lags between planting and harvesting, inadequate supportive infrastructure in the agricultural sector, and other factors that tend to slow down the process of adjustment to the equilibrium growth path.

The estimation and diagnostic testing of the long-run cointegrating relationship for the other crops that are included in this study, follows the same format and procedure as for banana. First, the vector of stochastic variables for each crop's ECM was specified as follows:

Sugar ECM: X_t = (lsugq, lsugpr, lbanpr, lwage, lferp)';

Coffee ECM: X_t = (lcofq, lcofpr, lbanpr, lwage, lferp)';

Pimento ECM: X_t = (lpimq, lpimpr, lbanpr, lwage, lferp)';

Yam ECM: X_t = (lyamq, lyampr, lcaspr, lwage, lferp)′;

Orange ECM: X_t = (lorq, lorgpr, lbanpr, lwage, lferp)′;

Cocoa-bean ECM: X_t = (lcobq, lcobpr, lbanpr, lwage, lferp)′;

Potato ECM: X_t = (lpotq, lpotpr, lcaspr, lwage, lferp)′;

where lsugq = sugar quantity; lsugpr = price of sugar; lcofq = coffee quantity; lcofpr = price of coffee; lpimq = pimento quantity; lpimpr = price of pimento; lyamq = yam quantity; lyampr = price of yam; lorq = orange quantity; lorpr = price of orange; lcobq = cocoa-bean quantity; lcobpr = price of cocoa bean; lpotq = potato quantity; lpotpr = price of potato. The ‘l’ that begins each variable name indicates logarithms, and all other variables are as previously defined.

Second, residual analysis was conducted to ensure that the models were appropriate for the data. Finally, the hypothesis of reduced rank is then tested on the matrix $\Pi = \alpha\beta'$, which defines the cointegrating vectors β and adjustment coefficients α. A normalization on the crop variable is taken, and the normalized β and α vector(s) is (are) reported.

The estimates of the β and α vectors for each crop are presented in Table 4.7. The first column in Table 4.7 lists

Table 4.7: Estimated Long-run and Adjustment Coefficients, β's, α's for all Crops.

Crops	Q	P_o	P_a	W	F	C
Banana						
β's	1	0.640	-0.156	-0.567	-0.106	-3.795
α's	-0.141 (-1.909)[b]	-0.352 (-1.949)[b]	0.511 (2.452)[a]	0.169 (3.469)[a]	0.097 (0.641)	
Sugar						
β's	1	0.155	-0.640	-0.106	-0.563	-3.290
α's	-0.141 (-2.899)[a]	0.511 (2.452)[a]	0.352 (1.949)[b]	0.169 (3.329)[a]	0.097 (2.641)[a]	
Coffee						
CE #1						
β's	1	0.969	0.291	-0.213	-0.724	-5.348
α's	-0.069 (-2.420)	-0.202 (-1.316)	-0.664 (-4.823)[a]	0.088 (1.617)	0.107 (1.326)	
CE #2						
β's	1	0.474	-0.005	-0.448	-2.938	6.503
α's	0.049 (2.717)[b]	-0.091 (-1.911)[c]	-0.100 (-1.930)[c]	-0.002 (-2.091)[b]	-0.193 (-5.697)[a]	
Pimento						
CE #1						
β's	1	0.576	-0.849	-0.534	-1.526	1.683
α's	-0.047 (-2.763)[a]	-0.318 (-6.173)[a]	0.031 (0.400)	0.004 (2.156)[b]	0.070 (2.455)[a]	
CE #2						
β's	1	-0.225	-0.026	0.542	0.468	-10.579
α's	-0.820 (-4.588)	0.140 (0.932)	0.200 (0.889)	-0.106 (-1.575)	-0.036 (-0.252)	
Yam						
CE #1						
β's	1	-3.755	5.138	0.484	1.225	-16.819
α's	-0.060 (-2.184)[b]	0.128 (2.813)[b]	-0.124 (-4.377)[a]	-0.012 (-0.539)	-0.098 (-2.125)[b]	
CE #2						
β's	1	0.418	-0.967	1.860	1.941	-23.344
α's	-0.186 (-4.718)[a]	-0.273 (-4.147)[a]	0.156 (3.808)[a]	-0.045 (-1.730)[c]	-0.028 (-0.427)	
CE #3						
β's	1	1.706	-2.958	-5.880	-1.700	23.210
α's	-0.033 (-2.851)[a]	-0.062 (-3.240)[a]	0.026 (2.184)[b]	0.021 (2.257)[b]	-0.042 (-2.189)[b]	
Orange						
β's	1	2.347	-1.620	-1.979	-1.492	11.270
α's	-0.139 (-1.472)	-0.366 (-1.858)	0.021 (0.094)	0.062 (2.134)	0.174 (3.047)	
Cocoa Bean						
β's	1	0.359	-0.081	-1.405	-0.983	-12.350
α's	-0.797 (-3.971)	0.676 (2.103)	-0.841 (-3.449)	-0.284 (-1.621)	-0.062 (-0.694)	

Table 4.7: Cont'd.

Crops	Q	P_o	P_a	W	F	C
Potato						
CE #1						
β's	1	1.952	-1.030	-5.197	0.704	-38.815
α's	-0.053 (-1.108)	-0.043 (-1.273)	0.077 (4.035)[a]	0.031 (3.052)[a]	-0.068 (-2.793)[a]	
CE #2						
β's	1	-0.251	0.220	0.127	0.323	-5.860
α's	-1.008 (-3.569)[a]	0.071 (2.364)[a]	-0.056 (-2.504)[a]	-0.018 (-1.999)[b]	-0.117 (-2.815)[a]	

Note: Figures in parentheses are t-values.
CE indicates 'cointegration equation'.
[a], [b], [c], indicate statistical significance at one, five and ten percent levels, respectively.
Q = quantity; P_o = own-price; P_a = price of the alternative crop; W = average wage rate in agriculture sector; F = average price of fertilizer; C = constant (intercept).

the crops, which are included in this study, followed by the β and α vectors. When there are more than one long-run cointegrating relationships, these are numbered as "CE #(.)" with the associated β and α vectors. Columns 2-6 indicate the variables and coefficients in the ECM for each crop, and column 7 records the intercepts. Thus, in the case of sugar, there is one long-run or cointegrating relationship, which, from Table 4.7, can be expressed as:

$$Q = -3.290 + 0.957P_o - 0.640P_a - 0.106W - 0.563F$$

where Q = quantity of sugar; P_o = own-price (i.e., price of sugar); P_a = price of alternative crop; W = average wage in agriculture; F = average price of fertilizer.

A number of inferences can be drawn from the information presented in Table 4.7. First, the long-run

relationship between supply and own-price is inelastic for five of the eight crops. Crops that are price elastic are yam, orange and potato, with own-price elasticities of 1.7, 2.3, and 2.0, respectively. The own-price elasticity coefficients reported in Table 4.7 are generally within the range estimated by other studies for Jamaica (see Table 3.1).

A second point to note with respect to the information in Table 4.7 is the relatively low elasticities with respect to the substitute crop price. For the banana ECM it is -0.16, for CE #2 in the coffee ECM, -0.01, and for sugar and cocoa-bean ECMs, -0.64 and -0.08 respectively. Relatively higher elasticities are recorded for the pimento -0.85, yam -3.0 , orange -1.62 and potato -1.03.

Third, the relationship between quantity and input-prices is generally inelastic. The exception are for wages in the yam and potato ECMs, and for fertilizer price in coffee, pimento, orange, and yam. Thus, in the cointegration equation #3 for yam, in the long-run a one percent increase in average agricultural wage will lead to a 6 percent fall in yam supply, other things remaining constant. A similar conclusion is arrived at for the first cointegrating relationship for potato. Similarly, the long-run relationship between supply and fertilizer price is

elastic for coffee (CE #2), pimento (CE #1) orange and yam (CE #3).

A fourth point to note with respect to Table 4.7 is about the adjustment coefficients α. Generally, the adjustment coefficients are significant. The exceptions include fertilizer price in the banana ECM, own-price, and wages in CE #1 for the coffee ECM, price of the alternative crop in CE #1 for the pimento ECM, and a few others. An insignificant adjustment coefficient, α_i, is a sign of weak exogeneity of the variable X_i in the vector of stochastic variables, X_t, in the ECM. Weak exogeneity means that although a long-run relationship exists between X_i and the other variables in X_t, X_i does not adjust to deviations from the long-run equilibrium. As such, any deviation from the long-run equilibrium in the system after a shock, is restored by adjustments made by variables other than X_i in the system (Johansen and Juselius, 1990, 1992). According to Johansen (1995), this does not preclude X_i from the cointegrating relationship in X_t.

An issue of some importance is raised here regarding the results in Table 4.7. This relates to the negative relationship observed between quantity and own-price for some of the crops, and what interpretation is possible in these cases. An examination of the data on quantity and

own-price reveals strong negative correlations for banana (-0.737), and sugar (-0.760), and modest negative quantity-own-price correlations for coffee (-.420) and potato (-0.390). The quantity-own-price correlations for the other crops are positive.

In Table 4.7 negative relations between quantity and own-price show up for pimento (CE #2), yam (CE #1) and potato (CE #2). Given the strong negative quantity-own-price correlation coefficients for banana and sugar, it is surprising that negative relations between quantity and price do not show up in the estimated cointegrating relationships for these two crops.

A number of possible explanations can be offered for these results. First, graphical examination of the quantity-own-price relationship reveals that the negative correlations are less pronounced than what the magnitude of the estimates would imply. Second, and as an extension of the previous point, the negative relationship is observed for specific and short period(s), rather than for the entire 1962-1999 period. In fact, in chapter 5 where supply functions are estimated for the eight crops over two sub-sample periods, 1962-1979 and 1980-1999, the negative quantity-own-price relations are more prevalent (see Tables 5.4, and 5.5, pp.157-160).

Third, error correction models based on cointegration account for the effects of not one or two, but of all the cointegrated variables in the system. In particular, the ECM technique provides a way of separating the long-run relationship between the economic variables ($y_t = \beta x_t$) from the short-run responses (i.e., the Δy_t, ΔX_t terms). In this regard, Engle and Granger (1987) have demonstrated that, asymptotically, these effects are dominated by the long-run relationships, and as the sample size becomes larger, the estimates of the cointegrating vector converges to the true value at a rate equal to T^{-1}, where T is the sample size. This rate of convergence is faster than the case where the variables are stationary, in which case the rate of convergence is $T^{-1/2}$. This is referred to as the super-consistency property of the estimates produced by ECMs. In effect, therefore, the estimates of the cointegrating vectors produced by ECMs based on cointegration, are not confined to, but rather, go beyond the simple correlations which may be observed between variables.

Finally, cases where the cointegrating relationships reveal a negative relationship between quantity and own-price, need to be commented on. It is tempting to interpret these cases as reflecting relationships on a demand function, i.e., a negative relationship between quantity

and own-price. However, this might not be a plausible explanation, since variables which would usually be included in a demand function such as consumer income, an index for consumer tastes, and other demand forcing variables, are not included in the crops' ECM. For those cases observed in Table 4.7, the strongest statement which could be offered for the negative relationships between quantity and own-price is that there is a long-run relationship observed for some crops, with possible properties of an incompletely specified real demand relationship.

The diagnostic statistics for model specification and tests for cointegration rank for each estimated ECM are shown in Appendix D. Graphs for residual analysis (not reported), similar to those for banana, were examined in conjunction with the diagnostic statistics. The residual analysis suggests that for all crops, the ECMs are appropriate for the data.

4.5 Analysis of Short-run Dynamics

The previous section suggests that the series in the crop ECMs are cointegrated. Since the cointegrated variables are in equilibrium, exogenous shocks to one of the variables in time t_0, will result in time paths of the system which will eventually stabilize to a new equilibrium

unless further shocks occur in the system. Lütkepohl and Reimers (1992), contend that these time paths provide insights into the short-run and long-run relationship between/among the variables in the system, especially in cases where there are more than one cointegrating relationships in an ECM. In this regard, innovation accounting (analysis of impulse response functions and variance decompositions) has become a useful tool in the analysis of cointegrated systems (Enders, 1995, 1996; Lütkepohl and Reimers, 1992).

The impulse response functions, specified as VARs, generate impact or dynamic multipliers. These coefficients capture the effects of exogenous shocks of each variable on its own time path, and on those of the other variables in the system, by imposing a recursive structure on the moving average representation of the VAR model (Enders, 1995). The moving average representation facilitates analysis of the interaction between sequences in the series of a VAR. Impulse response functions can be plotted to provide a visual representation of the behavior of each series in response to shocks in the system.

Identification of the parameters in the VAR necessitates imposing some structure (via parameters restrictions) on the system. One method of imposing

restrictions uses the Choleski decomposition (Doan, 1996). In this method, the ordering of the variables in the VAR is important and is based on statistical properties of the data as well as theoretical insights (Enders, 1995). However, the method can be tedious since, for example, in a five variable system there are 5!(=120) possible orderings of the variables.

Sims (1980) and Bernanke (1986) have proposed an alternative method of imposing restrictions for the identification of the VAR. In this scheme, exact identification of the structural model for an n-variable VAR necessitates $(n^2 - n)/2$ restrictions but additional (over identifying) restrictions can be imposed and tested statistically. The restrictions are based on economic theory.

The VAR in standard form (Enders, 1996), which is used for the impulse response analysis is specified as:

(4.7) $$X_t = A_0 + A_1X_{t-1} + A_2X_{t-2} + \ldots + AX_{t-p} + e_t$$

where:

$X_t = (\Delta Q,\ \Delta P_o,\ \Delta P_a,\ \Delta F,\ \Delta W)'$;

$X_{t-i} = (\Delta Q_{t-i},\ \Delta P_{o,t-i},\ \Delta P_{a,t-i},\ \Delta F_{,t-i},\ \Delta W_{,t-i})'$, $i = 1,2\ldots$

A_i = parameters to be estimated; e_t = vector of error terms. All other variables as previously defined.

Restrictions on (4.7) are based on the relationships that are specified in Table 4.8. In effect, the specification suggests that P_o, P_a, F and W are exogenous variables, and further, that innovations in any one of these variables will induce contemporaneous changes in itself and on Q, but on no other variable in the system. However, this specification, when combined with the Sims-Bernanke error variance decomposition, does not rule out induced changes in the other variables in future periods. This is to be expected, given that the variables are cointegrated.

Table 4.8: Endogenous and Exogenous Variables in Crops' Impulse Response Functions.

The Contemporaneous Value of:	Is Affected by the Contemporaneous value of:
Q	All variables in the system
P_o	No other variable
P_a	No other variable
F	No other variable
W	No other variable

Notes: Q = crop output; P_o = (own-price), i.e., price of output; P_a = price of substitute crop; F = fertilizer price; W = average agriculture wage rate.

Related to impulse response functions are forecast error variance decompositions, which provide information about the proportion of the movements in a variable due to its own shocks and to those from other variables in the

system (Enders, 1996). A twelve-period forecasting horizon is specified, and the Sims-Bernanke forecast error variance decompositions are used based on the restrictions implied in Table 4.8.

Impulses for 12 periods were examined for each crop's VAR and the first and second period results are reported in table format, while the plots for the entire forecast period are reported graphically. For all variables, the effects of the shocks after the fourth and fifth periods converge to zero or the equilibrium path, which is to be expected from a cointegrated system.

The results for the banana VAR are reported in Table 4.9. Thus, a one-standard-deviation shock in banana price (equal to 0.220 units) induces contemporaneous decrease of 0.165 units in banana quantity. By model specification, there is no contemporaneous change in the other variables. After one period, banana price is still 0.112 units above its mean, while banana quantity has increased by 0.076 units. In the second period, the shock in banana price has induced an increase in sugar price of 0.081 units, a decrease in fertilizer price of 0.007 units, and an increase in wage of 0.041 units. These effects are also shown graphically. As seen in Figures 4.7-4.14, equilibrium is achieved between the fourth and sixth periods.

Table 4.9: Responses of Banana Quantity to Shocks in the Banana VAR.

Responses to Shock in sugar price					
Period	dlsugpr	dlferp	dlwage	dlbanpr	Dlbanq
1	0.210	0	0	0	-0.162
2	0.071	0.020	-0.051	0.171	0.092
Responses to Shock in fertilizer price					
Period	dlsugpr	dlferp	dlwage	dlbanpr	dlbanq
1	0	0.150	0	0	-0.039
2	-0.007	0.023	-0.047	0.014	0.018
Responses to Shock in wage rate					
Period	dlsugpr	dlferp	dlwage	dlbanpr	dlbanq
1	0	0	0.055	0	0.002
2	-0.014	0.020	0.031	-0.018	0
Responses to Shock in banana price					
Period	dlsugpr	dlferp	dlwage	dlbanpr	dlbanq
1	0	0	0	0.220	-0.165
2	0.081	-0.007	0.041	0.112	0.076

Notes: The prefix 'd' to the variable names denotes change in the variable. All variables as previously defined.

To complement the results from the impulse response functions, the forecast error decompositions of the banana VAR are reported in Table 4.10. Enders (1996) argues that in applied research, it is typical for a variable to explain almost all of its forecast error variance at short horizons and smaller proportions at longer horizons. The Sims-Bernanke forecast error variance decompositions (based on restrictions specified in Table 4.8) reported in Table 4.10 show that each variable explains 100 percent of its forecast error variance in the first period. However, after the first period, the forecast error variance of a variable, which is explained by its own shock, falls. In

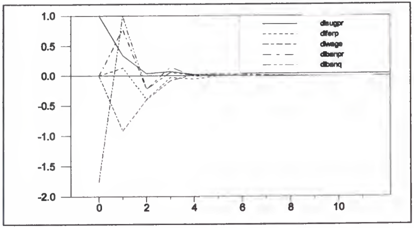

Figure 4.7: Impulse Responses to an Innovation in Sugar Price--Banana VAR.

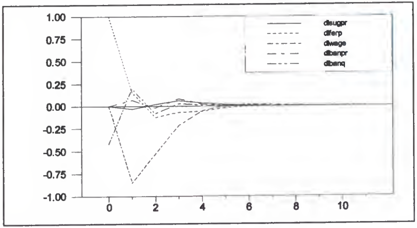

Figure 4.8: Impulse Responses to an Innovation in Fertilizer Price--Banana VAR.

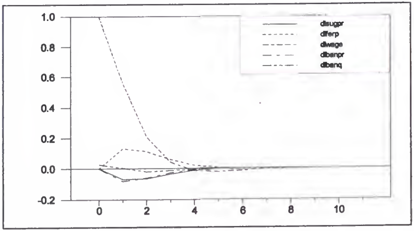

Figure 4.9: Impulse Responses to an Innovation in Wage--Banana VAR.

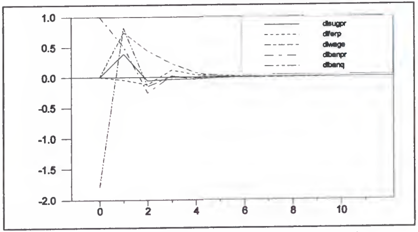

Figure 4.10: Impulse Responses to an Innovation in Banana Price--Banana VAR.

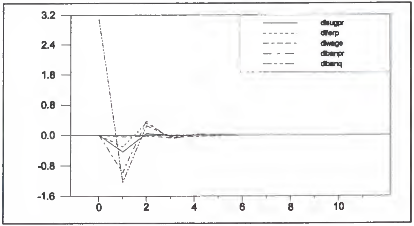

Figure 4.11: Impulse Responses to an Innovation in Banana Quantity--Banana VAR.

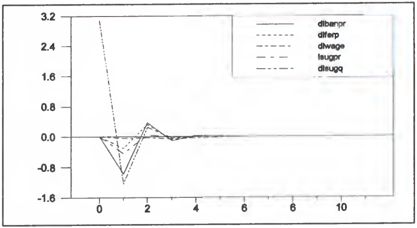

Figure 4.12: Impulse Responses to an Innovation in Sugar Quantity--Sugar VAR.

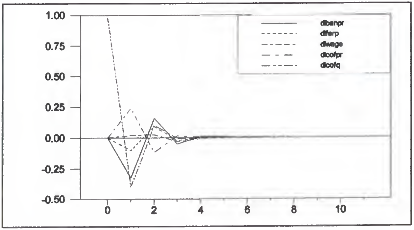

Figure 4.13: Impulse Responses to an Innovation in Coffee Quantity--Coffee VAR.

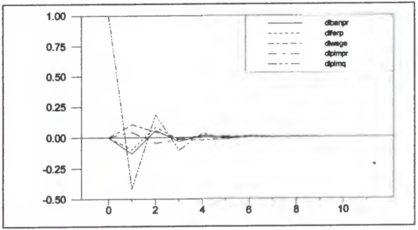

Figure 4.14: Impulse Responses to an Innovation in Pimento Quantity--Pimento VAR.

the case of the banana VAR, in the third period, sugar price explains 75.7 percent of its own forecast error variance, fertilizer price 71.2 percent, wage 33.0 percent, banana price 42.9 percent, and banana quantity 57.3 percent. These percentage distribution of the forecast error variance among the variables remain constant after the second and third forecast periods.

Table 4.10: Variance Decomposition Percentage of One-period and Three-period Forecast Error Variance--Banana VAR.

Forecast error variance in:	Percentage forecast error explained by shocks in:				
Sugar price	dlsugpr	dlferpr	dlwage	dlbanpr	dlbanq
1 Yr	100	0	0	0	0
3 yrs	75.712	0.105	0.613	10.395	13.176
Fertilizer price					
1 Yr	0	100	0	0	0
3 yrs	11.999	71.220	1.999	1.119	13.663
Wage					
1 Yr	0	0	100	0	0
3 yrs	24.430	24.341	32.961	18.196	0.072
Banana price					
1 Yr	0	0	0	100	0
3 yrs	21.262	0.149	0.340	42.880	35.368
Banana quantity					
1 Yr	19.407	1.105	0.004	19.940	59.543
3 yrs	21.416	1.147	0.006	20.094	57.337

The cross-variable effects are zero in the first period (by model specification), but change with the time horizon. In Table 4.10, the cross-variable effects in the third period show that the shock in banana price can

explain 43 percent of its own forecast error variance, shocks in banana quantity and sugar price account for 35 percent and 21 percent, respectively. Shocks in fertilizer price and the wage rate account for only 0.149 and 0.340 percent, respectively, of the forecast error variance in banana price. Similarly, in period three, the cross-price effect of a shock in fertilizer price can explain 71 percent of its own forecast error variance, while 14 percent and 12 percent are accounted for by shocks in banana quantity and sugar price, respectively. Finally, a shock in wage rate explains 33 percent of its own forecast error variance, while shocks in banana, fertilizer and sugar prices account for 18.2, 24.3 and 24.4 percent, respectively.

The last two rows in Table 4.10 show the forecast error variance decompositions when the exogenous variables (P_o, P_a, W, F) are modeled to impact banana quantity in all time periods. Thus, the banana quantity variable explains 60 percent of its own 1-step ahead forecast error variance, and 57 percent in the 3-step ahead forecast error variance. Similarly, in the first period, banana and sugar prices account for 20 percent and 19 percent of the forecast error variance in banana quantity, respectively. These percentages increase slightly in the 3-year ahead forecast.

Fertilizer price and wages account for negligible percentage variations in banana forecast error variance in both of the periods, suggesting thereby, the relative importance of own-price and price of the substitute crop on the short-run variations of banana quantity.

The estimates from the impulse response functions and forecast error decompositions for the other crops are reported in Tables 4.13-4.26. The associated plots of the impulse response functions are shown in Figures 4.15-4.46. In order to present the information in a manner that is succinct and easy to read, a major portion of the estimates that are reported in Tables 4.13-4.26 are summarized in Tables 4.11 and 4.12. Table 4.11 shows the responses of quantity to shocks in the exogenous variables in the system in periods one and two. Table 4.12 reproduces the last two rows of the tables that record the forecast error variance decompositions for the crops' ECM. That table shows the percentage forecast error variance in quantity, which is explained by the variables in the system.

The response of quantity to positive shocks in own-price (P_o) is expected to be positive. However, Table 4.11 shows that in period one, five of the eight crops (banana, sugar, yam, orange, and potato) show a decrease in output, which is induced by an own-price shock. Thus, in period one

Table 4.11: Responses of Quantity to Shocks in Exogenous Variables.

Variable	Period	Responses of Quantity to Shocks in:			
		P_o	P_a	W	F
Banana Quantity	1	-0.165	-0.162	0.002	-0.039
	2	0.076	0.092	0	0.018
Sugar Quantity	1	-0.162	-0.165	0.002	-0.039
	2	0.092	0.076	0	0.018
Coffee Quantity	1	0.021	-0.006	-0.016	0.004
	2	-0.005	0.021	0.009	0.004
Pimento Quantity	1	0.022	-0.006	-0.023	-0.021
	2	0.033	0.078	0.019	-0.090
Yam Quantity	1	-0.087	-0.008	-0.046	-0.019
	2	0.100	0.018	0.014	0.026
Orange Quantity	1	-0.038	0.061	0.097	0.025
	2	0.210	-0.148	-0.026	0.023
Cocoa Bean Quantity	1	0.007	0.028	0.031	0
	2	-0.062	-0.005	-0.046	0.006
Potato Quantity	1	-0.194	-0.026	-0.050	0.049
	2	0.177	-0.028	0.021	-0.012

Source: Tables 4.13, 4.15, 4.17, 4.19, 4.21, 4.23 and 4.25.

a one-standard-deviation-shock in banana price (equal to 0.220 units--see Table 4.13), induces a decrease in banana supply of 0.165 units. Other crops whose supply decrease in period one consequent upon a one-standard-deviation-shock in own-price are sugar (-0.162 units) and potato (-0.194 units). However, with the exception of coffee and cocoa-bean, all crops increase supply in the second period following a shock in own-price.

The response of quantity to positive shocks in the substitute crop price, P_a, wage, W, and fertilizer price, F, is expected to be negative. In period one this expectation is confirmed for shocks in P_a on all crop supply except

orange and cocoa-bean. Thus, in the case of coffee supply response, a one-standard-deviation-shock in banana price (equal to 0.223 units--see Table 4.15), induces a contemporaneous decrease in coffee supply of 0.006 units. Interestingly, in the second period, with the exception of orange, cocoa-bean and potato supply, shocks in the substitute crops' price induce positive response in crop supply response for the other crops.

Wage rate shocks appear to have negligible contemporaneous effect and no effect in period two on banana and sugar responses. Wage shocks do have negative contemporaneous effect on coffee, pimento, yam, and potato supply responses. However, in period two, it appears that wage shocks generally have a positive impact on short-run supply response. The exceptions are orange and cocoa-bean.

Finally, shocks in fertilizer price have negative contemporaneous effect on banana, sugar, pimento and yam supply response. However, with the exception of potato, and pimento, supply response of crops to a shock in fertilizer price are positive in period two.

Table 4.12 shows the proportion of forecast error variances in quantity, which are attributable to the variables that are specified as exogenous in the VARs for each crop. As previously mentioned, it is common for a

variable to explain a larger proportion of its contemporaneous forecast error variance and smaller proportions at later periods. This is generally the case for the crops shown in Table 4.12. Thus, 92 percent of coffee's contemporaneous forecast error variance is explained by its own shock, five percent by own-price (P_o), three percent by wage shocks and by negligible percentages in fertilizer and the substitute crop prices. However, in the third period, the percentage forecast error variance

Table 4.12: Summary of Forecast Error Variance in Crop Quantities Explained by Variables in the VAR (Percentage).

Forecast Error Variance in:	Period	Percentage of Forecast Error Variance in Quantity Explained by Shocks in:				
		P_a	F	W	P_o	Q
Banana	1	19.407	1.105	0.004	19.940	59.543
	3	21.416	1.147	0.006	20.094	57.337
Sugar	1	19.940	1.105	0.004	19.407	59.543
	3	20.094	1.147	0.006	21.416	57.337
Coffee	1	0.394	0.150	2.727	4.564	92.165
	3	4.732	0.805	2.857	3.950	87.655
Pimento	1	0.070	0.839	0.948	0.917	97.226
	3	7.285	10.403	2.914	1.959	77.439
Yam	1	0.127	0.653	3.691	13.330	82.199
	3	1.869	2.100	3.244	25.605	67.183
Orange	1	6.461	1.110	16.195	2.465	73.769
	3	21.606	1.548	5.842	43.470	27.534
Cocoa Bean	1	2.026	0	2.451	0.141	95.383
	3	1.588	0.133	6.502	11.047	80.730
Potato	1	0.714	2.626	2.711	40.583	53.367
	3	1.485	2.440	2.459	54.282	39.334

Source: Tables 4.14, 4.16, 4.18, 4.20, 4.22, 4.24 and4.26.

explained by coffee quantity shock reduces to 88 percent, while the proportion explained by the substitute crop price shock increases to five percent. Enders (1995, 1996) argues that if X_1 shocks do not explain any of the forecast error variance in X_2 in a VAR at all time horizons, then the X_2 sequence is exogenous. This means that the X_2 sequence evolves independently of shocks in X_1. On the other hand, if X_1 shocks explain all the forecast error variance in X_2 sequence at all forecast horizons, then X_2 is said to be endogenous. Neither of these two extreme cases are observed in Table 4.12.

With respect to the issues of endogeniety/exogeniety and the results reported in Table 4.12, one point must be noted. With only a few exceptions, shocks in fertilizer price and wages appear to explain relatively small proportions of the forecast error variance in quantity. The exceptions are pimento, orange and to some extent cocoa-bean. This is also true for the price of the substitute crop in the cases of coffee, cocoa-bean and potato.

Table 4.13: Responses of Sugar Quantity to Shocks in the Sugar VAR.

Responses to Shock in banana price					
Period	dlbanpr	dlferp	dlwage	dlsugpr	dlsugq
1	0.220	0	0	0	-0.165
2	0.112	-0.007	0.041	0.081	0.076
Responses to Shock in fertilizer price					
Period	dlbanpr	dlferp	dlwage	dlsugpr	dlsugq
1	0	0.150	0	0	-0.039
2	0.014	0.023	-0.047	-0.007	0.018
Responses to Shock in wage					
Period	dlbanpr	dlferp	dlwage	dlsugpr	dlsugq
1	0	0	0.055	0	0.002
2	-0.018	0.020	0.031	-0.014	0
Responses to Shock in sugar price					
Period	dlbanpr	dlferp	dlwage	dlsugpr	dlsugq
1	0	0	0	0.210	-0.162
2	0.171	0.020	-0.051	0.071	0.092

Notes: The prefix 'd' to the variable names denotes change in the variable. All variables previously defined.

Table 4.14: Variance Decomposition Percentage of One-period and Three-period Forecast Error Variance--Sugar VAR.

Forecast error variance in:	Percentage forecast error explained by shocks in:				
Banana price	dlbanpr	dlferpr	dlwage	dlsugpr	dlsugq
1 Yr	100	0	0	0	0
3 yrs	42.880	0.149	0.340	21.262	35.368
Fertilizer price					
1 Yr	0	100	0	0	0
3 yrs	1.119	71.220	1.999	11.999	13.663
Wage					
1 Yr	0	0	100	0	0
3 yrs	18.196	24.341	32.961	24.430	0.072
Sugar price					
1 Yr	0	0	0	100	0
3 yrs	10.395	0.105	0.613	75.712	13.176
Sugar quantity					
1 Yr	19.940	1.105	0.004	19.407	59.543
3 yrs	20.094	1.147	0.006	21.416	57.337

Table 4.15: Responses of Coffee Quantity to Shocks in the Coffee VAR.

Responses to Shock in banana price					
Period	dlbanpr	dlferp	dlwage	dlcofpr	dlcofq
1	0.223	0	0	0	-0.006
2	0.004	-0.034	0.023	0.003	0.021
Responses to Shock in fertilizer price					
Period	dlbanpr	dlferp	dlwage	dlcofpr	dlcofq
1	0	0.150	0	0	0.004
2	-0.006	0.014	-0.058	-0.082	0.007
Responses to Shock in wage					
Period	dlbanpr	dlferp	dlwage	dlcofpr	dlcofq
1	0	0	0.073	0	-0.016
2	-0.014	0.032	0.034	-0.005	0.009
Responses to Shock in coffee price					
Period	dlbanpr	dlferp	dlwage	dlcofpr	dlcofq
1	0	0	0	0.178	0.021
2	0.009	-0.015	0.014	-0.034	-0.005

Notes: The prefix 'd' to the variable names denotes change in the variable. All variables previously defined.

Table 4.16: Variance Decomposition Percentage of One-period and Three-period Forecast Error Variance--Coffee VAR.

Forecast error variance in:	Percentage forecast error explained by shocks in:				
Banana price	dlbanpr	dlferpr	dlwage	dlcofpr	dlcofq
1 Yr	100	0	0	0	0
3 yrs	87.482	0.080	1.039	0.180	11.219
Fertilizer price					
1 Yr	0	100	0	0	0
3 yrs	4.411	87.721	5.209	1.034	1.625
Wage					
1 Yr	0	0	100	0	0
3 yrs	8.878	38.064	50.623	2.393	0.041
Coffee price					
1 Yr	0	0	0	100	0
3 yrs	1.898	16.105	0.419	76.390	5.188
Coffee quantity					
1 Yr	0.394	0.150	2.727	4.564	92.165
3 yrs	4.732	0.805	2.857	3.950	87.655

Table 4.17: Responses of Pimento Quantity to Shocks in the Pimento VAR.

Responses to Shock in banana price					
Period	dlbanpr	dlferp	dlwage	dlpimpr	dlpimq
1	0.234	0	0	0	-0.006
2	0.001	-0.037	0.025	0.019	0.078
Responses to Shock in fertilize price					
Period	dlbanpr	dlferp	dlwage	dlpimpr	dlpimq
1	0	0.150	0	0	-0.021
2	-0.006	0.013	-0.056	-0.048	-0.090
Responses to Shock in wage					
Period	dlbanpr	dlferp	dlwage	dlpimpr	dlpimq
1	0	0	0.071	0	-0.023
2	-0.008	0.030	0.035	-0.063	0.019
Responses to Shock in pimento price					
Period	dlbanpr	dlferp	dlwage	dlpimpr	dlpimq
1	0	0	0	0.199	0.022
2	0.004	-0.010	0.015	-0.017	0.033

Notes: The prefix 'd' to the variable names denotes change in the variable. All variables previously defined.

Table 4.18: Variance Decomposition Percentage of One-period and Three-period Forecast Error Variance--Pimento VAR.

Forecast error variance in:	Percentage forecast error explained by shocks in:				
Banana price	dlbanpr	dlferpr	dlwage	dlpimpr	dlpimq
1 Yr	100	0	0	0	0
3 yrs	97.005	0.622	0.354	0.108	1.911
Fertilizer price					
1 Yr	0	100	0	0	0
3 yrs	5.401	87.773	4.943	0.456	1.427
Wage					
1 Yr	0	0	100	0	0
3 yrs	11.946	35.878	48.819	2.842	0.516
Pimento price					
1 Yr	0	0	0	100	0
3 yrs	0.913	8.551	10.265	79.974	0.298
Pimento quantity					
1 Yr	0.070	0.839	0.948	0.917	97.226
3 yrs	7.285	10.403	2.914	1.959	77.439

Table 4.19: Responses of Yam Quantity to Shocks in the Yam VAR.

Responses to Shock in cassava price					
Period	dlcaspr	dlferp	dlwage	dlyampr	dlyamq
1	0.119	0	0	0	-0.008
2	0.046	0.044	-0.033	0.051	0.018
Responses to Shock in fertilizer price					
Period	dlcaspr	dlferp	dlwage	dlyampr	dlyamq
1	0	0.147	0	0	-0.019
2	-0.037	0.002	-0.047	-0.018	0.026
Responses to Shock in wage					
Period	dlcaspr	dlferp	dlwage	dlyampr	dlyamq
1	0	0	0.064	0	-0.046
2	0.007	0.022	0.035	0.007	0.014
Responses to Shock in yam price					
Period	dlcaspr	dlferp	dlwage	dlyampr	dlyamq
1	0	0	0	0.179	-0.087
2	-0.013	-0.031	0.038	-0.023	0.100

Notes: The prefix 'd' to the variable names denotes change in the variable. All variables previously defined.

Table 4.20: Variance Decomposition Percentage of One-period and Three-period Forecast Error Variance--Yam VAR.

Forecast error variance in:	Percentage forecast error explained by shocks in:				
Cassava price	dlcaspr	dlferpr	dlwage	dlyampr	dlyamq
1 Yr	100	0	0	0	0
3 yrs	84.304	8.617	0.466	1.210	5.404
Fertilizer price					
1 Yr	0	100	0	0	0
3 yrs	7.353	83.702	2.931	4.949	1.064
Wage					
1 Yr	0	0	100	0	0
3 yrs	17.798	20.621	43.241	17.782	0.558
Yam price					
1 Yr	0	0	0	100	0
3 yrs	6.503	1.294	0.321	83.129	8.752
Yam quantity					
1 Yr	0.127	0.653	3.691	13.330	82.199
3 yrs	1.869	2.100	3.244	25.605	67.183

Table 4.21: Responses of Orange Quantity to Shocks in the Orange VAR.

Responses to Shock in grapefruit price					
Period	dlgrpr	dlferp	dlwage	dlorpr	dlorq
1	0.523	0	0	0	0.061
2	-0.103	0.027	-0.038	0.081	-0.148
Responses to Shock in fertilizer price					
Period	dlgrpr	dlferp	dlwage	dlorpr	dlorq
1	0	0.148	0	0	0.025
2	-0.088	0.012	-0.045	-0.122	0.023
Responses to Shock in wage					
Period	dlgrpr	dlferp	dlwage	dlorpr	dlorq
1	0	0	0.072	0	0.097
2	-0.052	0.042	0.039	-0.107	-0.026
Responses to Shock in orange price					
Period	dlgrpr	dlferp	dlwage	dlorpr	dlorq
1	0	0	0	0.477	-0.038
2	0.124	0.023	0.042	-0.201	0.210

Notes: The prefix 'd' to the variable names denotes change in the variable. All variables previously defined.

Table 4.22: Variance Decomposition Percentage of One-period and Three-period Forecast Error Variance--Orange VAR.

Forecast error variance in:	Percentage forecast error explained by shocks in:				
Grapefruit price	dlgrpr	dlferpr	dlwage	dlorpr	dlorq
1 Yr	100	0	0	0	0
3 yrs	84.559	2.263	1.511	10.961	0.705
Fertilizer price					
1 Yr	0	100	0	0	0
3 yrs	4.577	83.741	7.159	4.251	0.272
Wage					
1 Yr	0	0	100	0	0
3 yrs	12.886	22.566	50.088	13.979	0.480
Orange price					
1 Yr	0	0	0	100	0
3 yrs	2.306	5.298	3.512	83.017	5.867
Orange quantity					
1 Yr	6.461	1.110	16.195	2.465	73.769
3 yrs	21.606	1.548	5.842	43.470	27.534

Table 4.23: Responses of Cocoa-bean Quantity to Shocks in the Cocoa-bean VAR.

Responses to Shock in banana price					
Period	dlbanpr	dlferp	dlwage	dlcobpr	dlcobq
1	0.225	0	0	0	0.028
2	0.013	-0.048	0.022	-0.030	-0.005
Responses to Shock in fertilizer price					
Period	dlbanpr	dlferp	dlwage	dlcobpr	dlcobq
1	0	0.146	0	0	0
2	-0.015	0.025	-0.056	0.093	0.006
Responses to Shock in wage					
Period	dlbanpr	dlferp	dlwage	dlcobpr	dlcobq
1	0	0	0.072	0	0.031
2	-0.011	0.027	0.037	0.073	-0.046
Responses to Shock in cocoa-bean price					
Period	dlbanpr	dlferp	dlwage	dlcobpr	dlcobq
1	0	0	0	0.275	0.007
2	0.032	-0.031	-0.004	-0.083	-0.062

Notes: The prefix 'd' to the variable names denotes change in the variable. All variables previously defined.

Table 4.24: Variance Decomposition Percentage of One-period and Three-period Forecast Error Variance--Cocoa-bean VAR.

Forecast error variance in:	Percentage forecast error explained by shocks in:				
Banana price	dlbanpr	dlferpr	dlwage	dlcobpr	dlcobq
1 Yr	100	0	0	0	0
3 yrs	90.042	1.424	0.760	2.612	5.163
Fertilizer price					
1 Yr	0	100	0	0	0
3 yrs	8.454	81.851	3.994	3.370	2.331
Wage					
1 Yr	0	0	100	0	0
3 yrs	11.070	35.763	48.791	2.466	1.910
Cocoa bean price					
1 Yr	0	0	0	100	0
3 yrs	0.857	11.874	5.585	77.946	3.738
Cocoa-bean quantity					
1 Yr	2.026	0	2.451	0.141	95.383
3 yrs	1.588	0.133	6.502	11.047	80.730

Table 4.25: Responses of Potato Quantity to Shocks in the Potato VAR.

Responses to Shock in cassava price					
Period	dlcaspr	dlferp	dlwage	dlpotpr	dlpotq
1	0.125	0	0	0	-0.026
2	0.045	0.049	-0.036	0.050	-0.028
Responses to Shock in fertilizer price					
Period	dlcaspr	dlferp	dlwage	dlpotpr	dlpotq
1	0	0.148	0	0	0.049
2	-0.037	0.001	-0.046	-0.020	-0.012
Responses to Shock in wage					
Period	dlcaspr	dlferp	dlwage	dlpotpr	dlpotq
1	0	0	0.062	0	-0.050
2	0.003	0.025	0.030	0.008	0.021
Responses to Shock in potato price					
Period	dlcaspr	dlferp	dlwage	dlpotpr	dlpotq
1	0	0	0	0.187	-0.194
2	-0.017	-0.030	0.039	-0.029	0.177

Notes: The prefix 'd' to the variable names denotes change in the variable. All variables previously defined.

Table 4.26: Variance Decomposition Percentage of One-period and Three-period Forecast Error Variance--Potato VAR.

Forecast error variance in:	Percentage forecast error explained by shocks in:				
Cassava price	dlcaspr	dlferpr	dlwage	dlpotpr	dlpotq
1 Yr	100	0	0	0	0
3 yrs	90.133	7.985	0.168	1.591	0.123
Fertilizer price					
1 Yr	0	100	0	0	0
3 yrs	8.889	84.140	2.715	3.706	0.550
Wage					
1 Yr	0	0	100	0	0
3 yrs	19.565	19.787	36.307	22.798	1.543
Potato price					
1 Yr	0	0	0	100	0
3 yrs	6.058	1.034	0.269	89.234	3.405
Potato quantity					
1 Yr	0.714	2.626	2.711	40.583	53.367
3 yrs	1.485	2.440	2.459	54.282	39.334

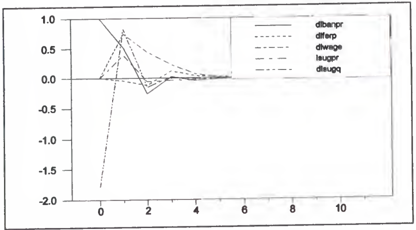

Figure 4.15: Impulse Responses to an Innovation in Banana Price--Sugar VAR.

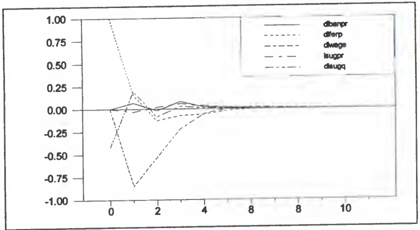

Figure 4.16: Impulse Responses to an Innovation in Fertilizer Price--Sugar VAR.

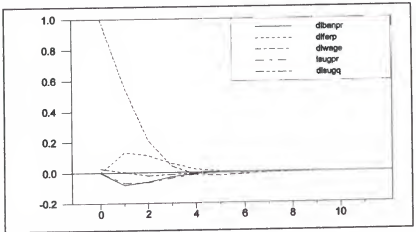

Figure 4.17: Impulse Responses to an Innovation in Wage--Sugar VAR.

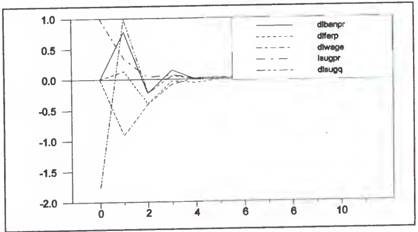

Figure 4.18: Impulse Responses to an Innovation in Sugar Price--Sugar VAR.

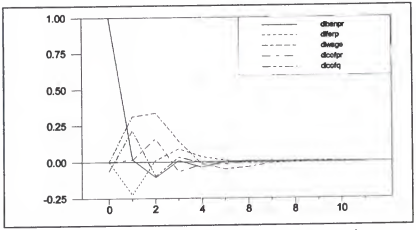

Figure 4.19: Impulse Responses to an Innovation in Banana Price--Coffee VAR.

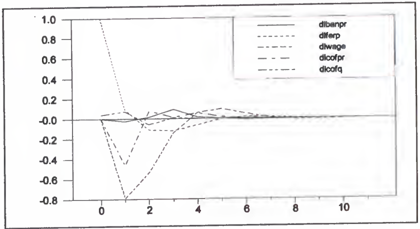

Figure 4.20: Impulse Responses to an Innovation in Fertilizer Price--Coffee VAR.

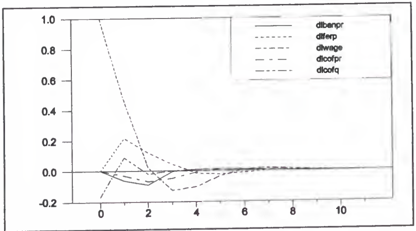

Figure 4.21: Impulse Responses to an Innovation in Wage--Coffee VAR.

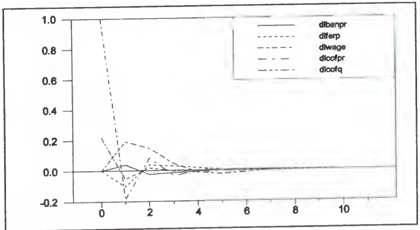

Figure 4.22: Impulse Responses to an Innovation in Coffee Price--Coffee VAR.

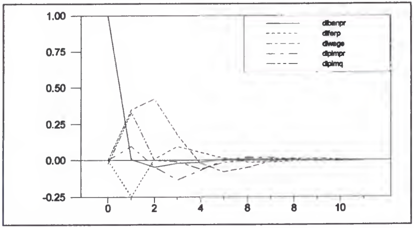

Figure 4.23: Impulse Responses to an Innovation in Banana Price--Pimento VAR.

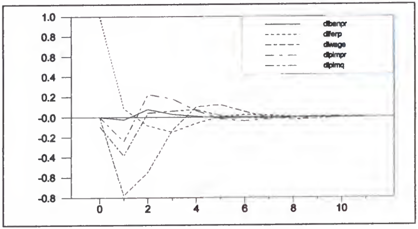

Figure 4.24: Impulse Responses to an Innovation in Fertilizer Price--Pimento VAR.

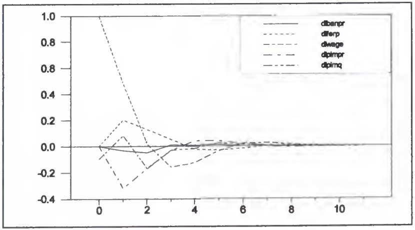

Figure 4.25: Impulse Responses to an Innovation in Wage--Pimento VAR.

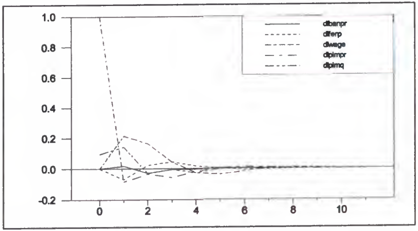

Figure 4.26: Impulse Responses to an Innovation in Pimento Price--Pimento VAR.

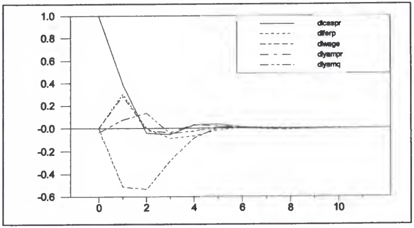

Figure 4.27: Impulse Responses to an Innovation in Cassava Price--Yam VAR.

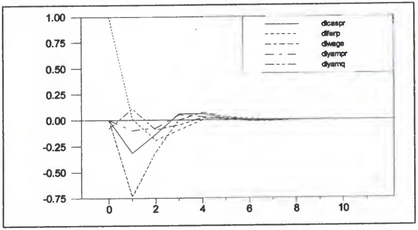

Figure 4.28: Impulse Responses to an Innovation in Fertilizer Price--Yam VAR.

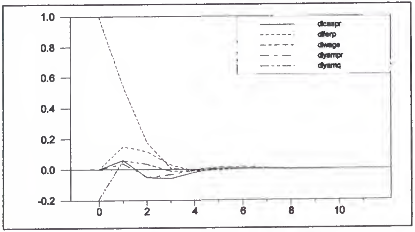

Figure 4.29: Impulse Responses to an Innovation in Wage--Yam VAR.

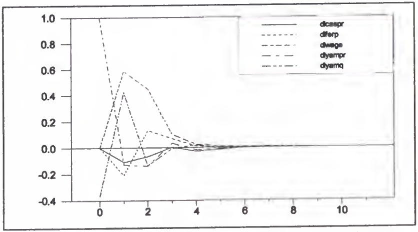

Figure 4.30: Impulse Responses to an Innovation in Yam Price--Yam VAR.

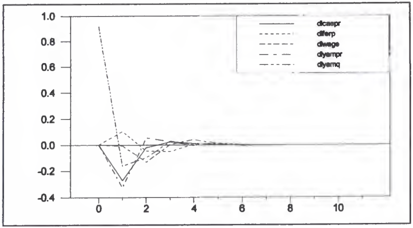

Figure 4.31: Impulse Responses to an Innovation in Yam Quantity--Yam VAR.

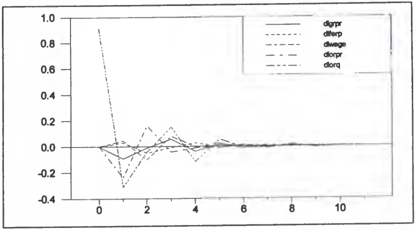

Figure 4.32: Impulse Responses to an Innovation in Orange Quantity--Orange VAR.

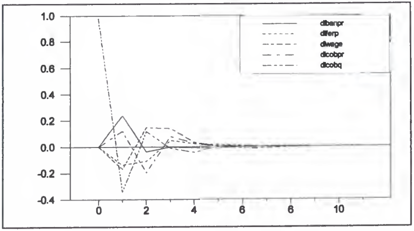

Figure 4.33: Impulse Responses to an Innovation in Cocoa-bean Quantity--Cocoa-bean VAR.

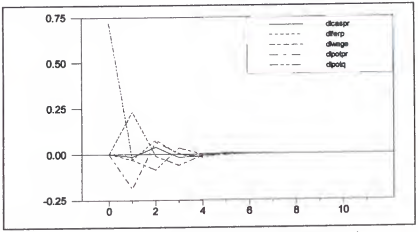

Figure 4.34: Impulse Responses to an Innovation in Potato Quantity--Potato VAR.

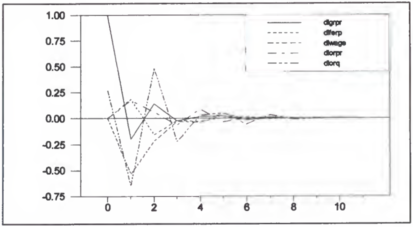

Figure 4.35: Impulse Responses to an Innovation in Grapefruit Price--Orange VAR.

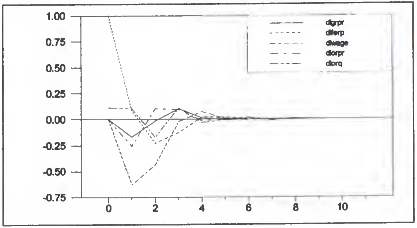

Figure 4.36: Impulse Responses to an Innovation in Fertilizer Price--Orange VAR.

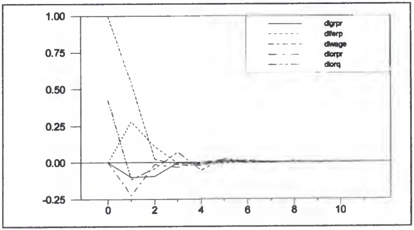

Figure 4.37: Impulse Responses to an Innovation in Wage--Orange VAR.

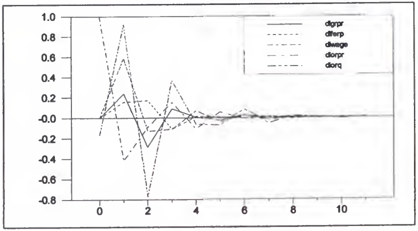

Figure 4.38: Impulse Responses to an Innovation in Orange Price--Orange VAR.

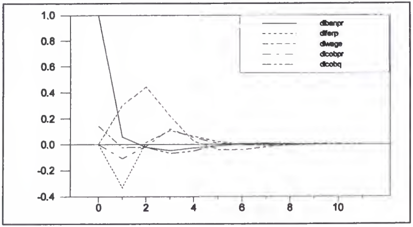

Figure 4.39: Impulse Responses to an Innovation in Banana Price--Cocoa-bean VAR.

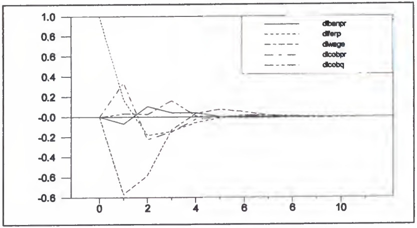

Figure 4.40: Impulse Responses to an Innovation in Fertilizer Price--Cocoa-bean VAR.

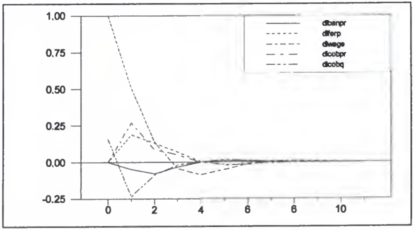

Figure 4.41: Impulse Responses to an Innovation in Wage--Cocoa-bean VAR.

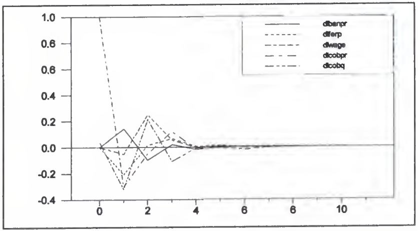

Figure 4.42: Impulse Responses to an Innovation in Cocoa-bean Price--Cocoa-bean VAR.

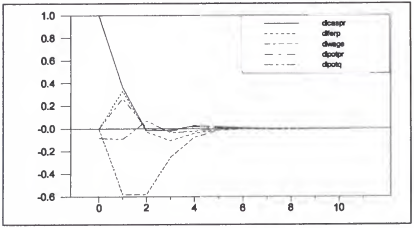

Figure 4.43: Impulse Responses to an Innovation in Cassava Price--Potato VAR.

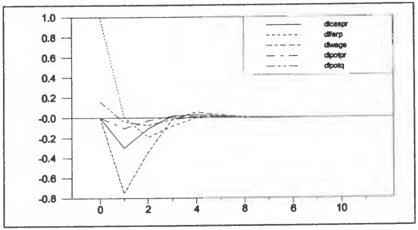

Figure 4.44: Impulse Responses to an Innovation in Fertilizer Price--Potato VAR.

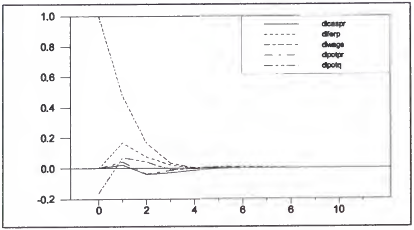

Figure 4.45: Impulse Responses to an Innovation in Wage--Potato VAR.

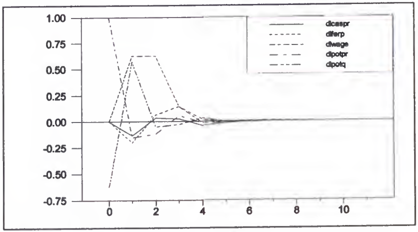

Figure 4.46: Impulse Responses to an Innovation in Potato Price--Potato VAR.

4.6 Summary

This chapter provides empirical evidence of long-run equilibrium or cointegrating relationships between crop output and price incentives for eight crops grown in Jamaica. It was found that the data series relevant to the estimation of the long-run relationships are non-stationary. This statistical quality of the data has not been taken into consideration in previous studies on crop supply responses in Jamaica's agricultural sector. To deal with this data problem, an error correction modeling approach based on cointegration theory was adopted, within an estimation framework developed by Johansen (1988).

The results from the estimation found low own-price elasticities as well as low adjustment coefficients. Additionally, impulse functions and forecast error variances were estimated in order to analyze the short-run dynamics of the output-price incentive relationships. It was found that overall, it appears that short-run crop responses are low, and respond more to crop price variations than on input-price changes. Slow adjustments in the short-run may be a sign of constraining government regulations, inadequate supportive infrastructure, lags between planting and harvesting, and other reasons.

CHAPTER 5
SUPPLY RESPONSE AND COUNTERFACTUAL ANALYSIS

In this chapter the before-after approach and counter-factual analysis are used to assess the impact of the economic reforms on crop supply response in Jamaica. The before-after analysis is done in Section 5.1, and the counterfactual analysis in Section 5.2.

5.1 Before-After Analysis

The before-after approach compares the performances of target economic variables during a particular program regime with their performances prior to the program. The approach assumes that any changes in the variables in the reform period are attributed solely to the reforms in that period. Two before-after estimators, which have been used extensively in the literature to evaluate Fund/Bank economic reform programs, are the mean change in the target variable and its variance (Khan, 1990). The mean estimator can be expressed as $\Delta Y = Y_2 - Y_1$, where Y_2 and Y_1 are the means of the variable in the reform and pre-reform periods, respectively. If $\Delta Y > 0$, this is interpreted to mean that the reforms impacted positively on the variables.

Price-variability is measured by the coefficient of variation, expressed as $CV = \frac{\hat{s}}{\overline{x}}$, where $\hat{s}$, and $\overline{x}$ are the standard deviation and mean respectively. A brief justification for using these estimators is warranted here.

One of the primary aims of the economic reforms in agriculture is to provide farmers with prices that are remunerative enough to induce output growth. Indeed, the observation that government interventions have been historically biased against agriculture (Schiff and Valdés, 1992a), led naturally to the belief by the IMF and World Bank that the economic reforms would reduce government distortion of prices, and improve price and non-price incentives to agriculture (World Bank, 1996). In this regard, it seems logical to investigate whether the reforms have ushered-in stimulative prices in agriculture.

However, a related but antecedent question is what constitutes a stimulative price shift? Given the biological lag between planting and harvesting in agriculture, and the observation that in developing countries few farmers can fully mitigate against temporal price risk because of lack of resources, modern microeconomic theory provides little predictive confidence on agricultural production response to a given shift in the price distribution. However, micro-

economic theory of the firm under price uncertainty does postulate a positive relationship between output and the mean of output price, and a negative relationship between output and the variance of output price (Baron, 1970; Sandmo, 1971; Ishii, 1977).

The issues raised above therefore justify an empirical examination of the first two moments of the price and quantity series used in the crop supply response models. In order to facilitate comparative analysis of variability among the different crops, the coefficient of variation is used instead of the variance. As mentioned in chapter 1, the period 1962-1979 is considered as the pre-reform period, and 1980-1999 the reform period. Two sets of estimates of the means and coefficients of variation for all eight crops' output and prices are computed. The first set covers the entire pre-reform and the reform periods, and the second set uses observations from the last five years in the pre-reform, and the first five years in the reform periods, respectively. These estimates are reported in Tables 5.1 and 5.2, and are robust with respect to the time periods used.

With respect to quantity, Table 5.1 shows that the mean output was higher in the reform period for four of the eight crops analyzed. These are coffee, pimento, yam and

Table 5.1: Descriptive Price and Quantity Statistics --1962-1979 and 1980-1999.

Variable	Pre-Reform Period 1962-1979		Reform Period 1980-1999	
	Mean	CV	Mean	CV
banq	134.771	0.189	98.274	0.086
banpr	2.978	0.398	8.436	0.242
sugq	175.214	0.204	93.300	0.088
sugpr	0.419	0.169	5.542	0.577
cofq	70.603	0.218	92.263	0.309
cofpr	41.021	0.219	21.485	0.229
pimq	189.586	0.197	339.261	0.148
pimpr	63.750	0.429	21.555	0.238
yamq	74.936	0.357	135.259	0.226
yampr	7.297	0.141	9.227	0.593
orq	142.996	0.331	135.266	0.315
orpr	1.575	0.364	11.000	0.967
cobq	104.918	0.133	120.861	0.240
cobpr	19.774	0.464	16.600	0.494
potq	162.886	0.237	152.036	0.307
potpr	8.654	0.212	12.390	0.382
ferp	9.432	0.219	8.215	0.214
wage	283.077	0.191	246.531	0.190

Note: $CV = \hat{s}/\bar{x}$, is the coefficient of variation, where, $\hat{s}$ and $\bar{x}$ are the standard deviation and mean respectively. All other variables as previously defined.

cocoa-bean. These increases in output are likely due to the government expansion programs in these crop activities, such as coffee and cocoa-bean rehabilitation schemes by the government, and to the stimulus of increased prices and export opportunities following the liberalization of prices in the reform period. With regards to the crops whose mean output did not increase over the reform period (banana, sugar, orange and potato), this is likely due to the

Table 5.2: Descriptive Price and Quantity Statistics --1975-1979 and 1980-1984.

Variable	Last 5 years of Pre-Reform Period 1975-1979		First 5 years of Reform Period 1980-1984	
	Mean	CV	Mean	CV
banq	105.833	0.118	109.286	0.055
banpr	4.428	0.186	7.771	0.393
sugq	141.758	0.130	89.588	0.094
sugpr	0.482	0.161	1.525	0.592
cofq	62.004	0.245	76.606	0.189
cofpr	48.084	0.165	21.103	0.152
pimq	193.388	0.241	214.163	0.425
pimpr	40.569	0.257	20.414	0.035
yamq	102.466	0.107	100.227	0.087
yampr	8.513	0.147	10.572	0.123
orq	94.350	0.145	78.325	0.017
orpr	1.116	0.591	1.061	0.089
cobq	94.169	0.095	125.868	0.207
cobpr	25.660	0.735	24.911	0.071
potq	162.018	0.266	133.925	0.321
potpr	10.746	0.112	11.568	0.139
ferp	10.020	0.246	9.175	0.219
wage	328.513	0.119	233.430	0.036

Notes: $CV = \hat{s}/\overline{x}$, is the coefficient of variation, where, $\hat{s}$ and $\overline{x}$ are the standard deviation and mean respectively. All other variables as previously defined.

persistence of structural factors, which slow down the adjustment process of output to policy changes.

Table 5.1 also shows that mean real prices for five crops (banana, sugar, yam, orange, and potato), increased over the reform period. The exceptions are coffee, pimento and cocoa-bean. However, real price-variability appears to have increased for most crop prices over the reform period. The exceptions are banana and pimento. Thus, the

coefficient of variation for sugar price was 17 percent in the pre-reform period, but increased to 58 percent in the reform period. Similar high coefficients of variations are recorded for other crop prices. The observations made above in connection to the information in Table 5.1 are in general agreement with the information in Table 5.2.

In addition to the information in Tables 5.1 and 5.2, Figures 5.1-5.8 show changes in nominal and real crop prices over the period 1962-1999. For most crops, nominal prices shifted upwards from the late 1970s and early 1980s, but the most dramatic increases are observed from the late 1980s onwards.

While nominal prices have been increasing in the reform period, real prices show mixed changes as shown in Figures 5.5-5.8. Real prices for coffee and pimento have declined steadily over the 1962-1999 period. Some price stability and windfall gains have been observed for cocoa-bean and potato prices but they seem to be on the descent, since 1987, below levels observed in the earlier years. The real prices for yam and orange increased briefly after the announced price liberalization policies by the government in 1985. By 1994 both prices were on the down turn but trending above the pre-liberalized price regime. Finally, real prices for banana and coffee showed dramatic increases

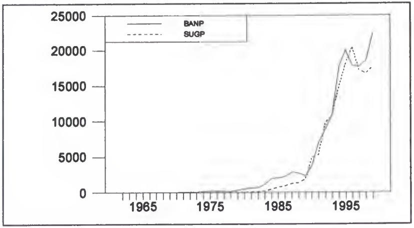

Figure 5.1: Nominal Price Changes--Banana (BANP) and Sugar (SUGP).

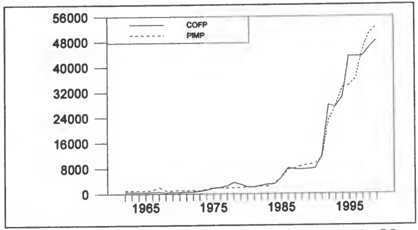

Figure 5.2: Nominal Price Changes--Coffee (COFP) and Pimento (PIMP).

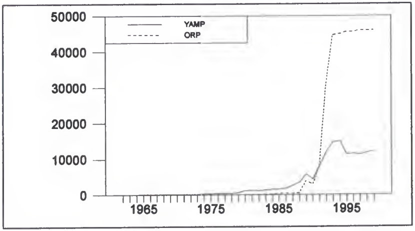

Figure 5.3: Nominal Price Changes--Yam (YAMP) and Orange (ORP).

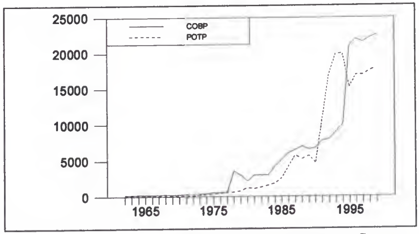

Figure 5.4: Nominal Price Changes--Cocoa-bean (COBP) and Potato (POTP).

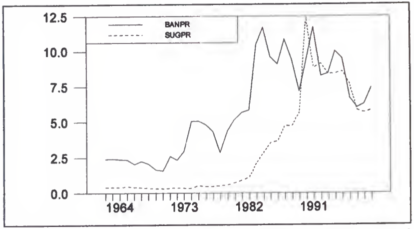

Figure 5.5: Real Price Changes--Banana and Sugar (1980=100).

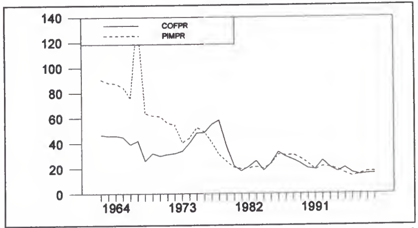

Figure 5.6: Real Price Changes--Coffee and Pimento (1980=100).

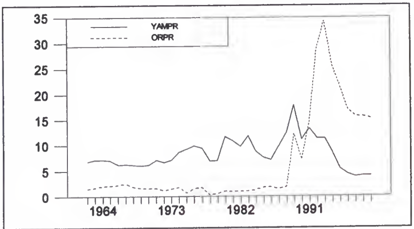

Figure 5.7: Real Price Changes--Yam and Orange (1980=100).

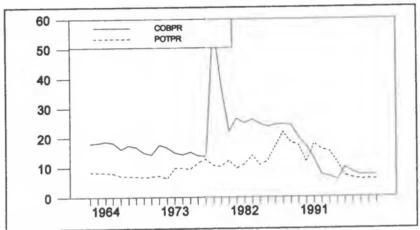

Figure 5.8: Real Price Changes--Cocoa-bean and Potato (1980=100).

in the early 1980s, and while sugar price continued upwards until 1991, banana price peaked in 1985, fluctuated somewhat, and along with sugar, have been on a decline, with some evidence of an upturn by 1998.

In effect, therefore, these observations suggest that the pro-competitive effects that were expected to accompany the reforms as well as from the demise of state monopolies, may have outweighed the stability impulses of controlled prices of the pre-reform era.

5.2 Counterfactual Analysis

One of the premises upon which the long-run supply elasticities reported in chapter 4 is based, is that the recent economic reforms in Jamaica influenced the variation of the economic time series which are included in the various crops' error correction models. On the basis of this premise, the long-run crop supply elasticities reported in chapter 4 could be interpreted as what has happened to supply response under the economic reforms.

However, the true effect of the economic reforms on crop supply response must be based upon a comparison of the supply response estimates in chapter 4 with estimates derived under the assumption that the economic reforms, which were observed over the period 1980-1999 did not occur. Crop supply response under this assumption would

constitute a counterfactual, against which the supply response estimates in chapter 4 should be compared. A relevant issue, in this regard, is what would have been the policies pursued by the government if the reforms were not undertaken? Answers to this question would provide the counterfactual situations.

The most manageable way of constructing a counterfactual using time series data, is to assume that the policies, which the government was pursuing over the 1962-1979 period, continued over the 1980-1999 period. Under this assumption, the time series modeling technique would forecast the 1980-1999 period by extrapolating techniques, which incorporate no information other than that available in the past. A central issue, however, is whether the forecasts should be made on individual series or as a system. Since in each crop supply response ECM the variables are shown to be in long-run equilibrium, it seems justifiable to use a systems approach to forecasting the economic time series. As such, a VAR approach is utilized and in each VAR the stochastic variables are the same as those that were included in the supply response ECM in chapter 4.

The forecasts of the economic time series are shown in Figures 5.9-5.28. Although the graphs show clear distinct-

ions between the actual and forecasted variables, for some crops the two sets of series show mixed results. For example, Figure 5.9 shows that the forecast of banana quantity is above the actual series over the 1980-1999 period (the exception is in 1983 when actual and forecast quantities are equal). Similarly, Figure 5.11 shows that actual price of sugar has been above the forecast for the entire 1980-1999 period. Given the assumption under which the forecasts were made, this suggests that, in the case of Figure 5.9, if past (1962-1979) policies had continued over the 1980-1999 period, banana output would have been higher than what actually prevailed during the period of economic reforms. This would have been the case despite the fact that the forecasted banana price is lower than actual price.

The one-step ahead forecasts shown in Figures 5.9-5.28 suffer from two short-comings. First, they reflect the data trend of the last few years before the end of 1980. Further, the forecasts are smooth and do not reflect the fluctuations in the actual series. Finally, the forecasts were plagued with large standard errors, and therefore provide only a possible indication rather than a precise picture of the counterfactuals.

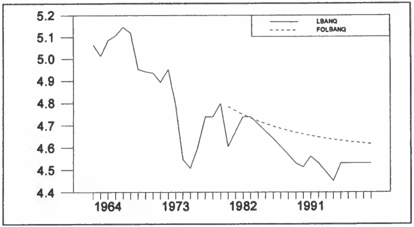

Figure 5.9: Banana Quantity--Actual (LBANQ) and Forecasted (FOLBANQ).

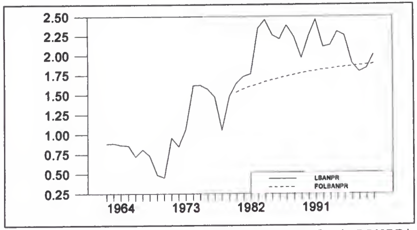

Figure 5.10: Banana Price--Actual (LBANPR) and Forecasted (FOLBANPR).

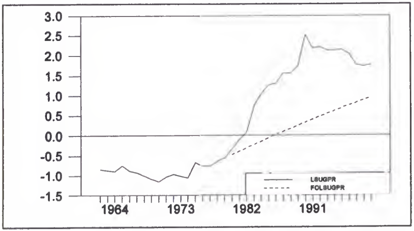

Figure 5.11: Sugar Price--Actual (LSUGPR) and Forecasted (FOLSUGPR).

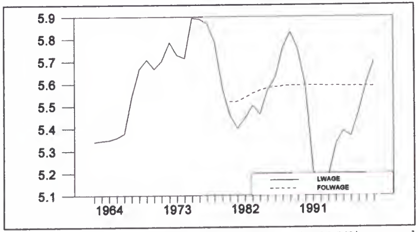

Figure 5.12: Wage--Actual (LWAGE) and Forecasted (FOLWAGE).

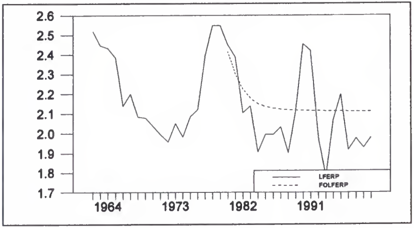

Figure 5.13: Fertilizer Price--Actual (LFERP) and Forecasted (FOLFERP).

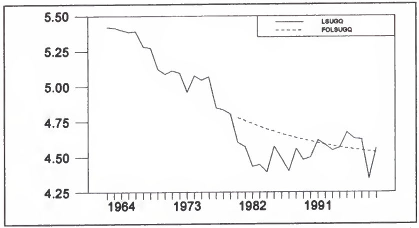

Figure 5.14: Sugar Quantity--Actual (LSUGQ) and Forecasted (FOLSUGQ).

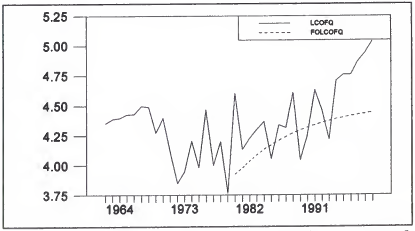

Figure 5.15: Coffee Quantity--Actual (LCOFQ) and Forecasted (FOLCOFQ).

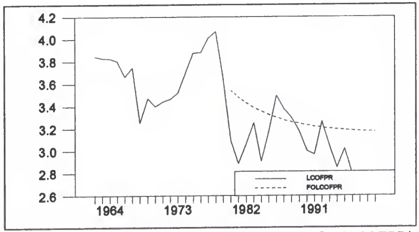

Figure 5.16: Coffee Price--Actual (LCOFPR) and Forecasted (FOLCOFPR).

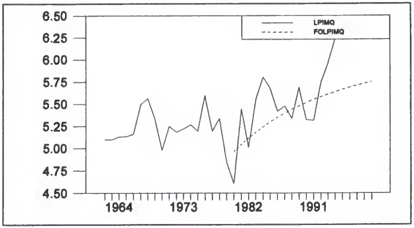

Figure 5.17: Pimento Quantity--Actual (LPIMQ) and Forecasted (FOLPIMQ).

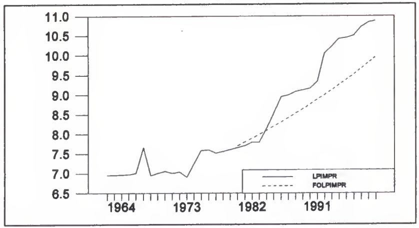

Figure 5.18: Pimento Price--Actual (LPIMPR) and Forecasted (FOLPIMPR).

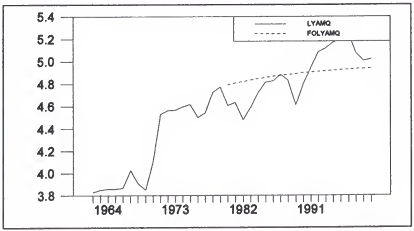

Figure 5.19: Yam Quantity--Actual (LYAMQ) and Forecasted (FOLYAMQ).

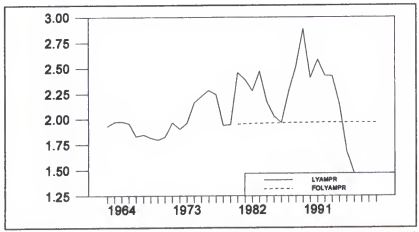

Figure 5.20: Yam Price--Actual (LYAMPR) and Forecasted (FOLYAMPR).

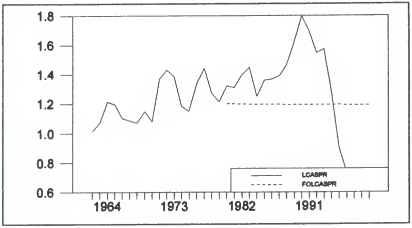

Figure 5.21: Cassava Price--Actual (LCASPR) and Forecasted (FOLCASPR).

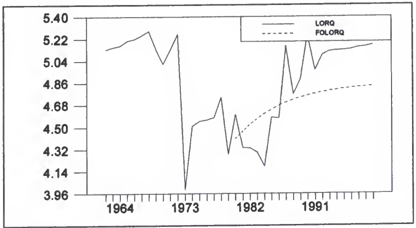

Figure 5.22: Orange Quantity--Actual (LORQ) and Forecasted (FOLORQ).

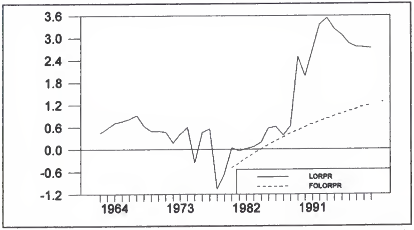

Figure 5.23: Orange Price--Actual (LORPR) and Forecasted (FOLORPR).

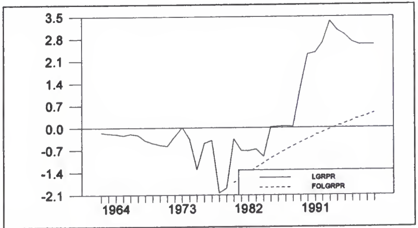

Figure 5.24: Grapefruit Price--Actual (LGRPR) and Forecasted (FOLGRPR).

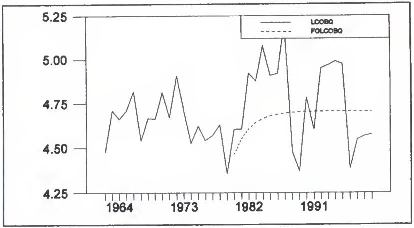

Figure 5.25: Cocoa-bean Quantity--Actual (LCOBQ) and Forecasted (FOLCOBQ).

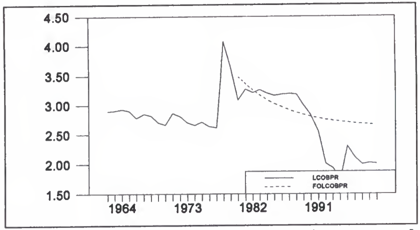

Figure 5.26: Cocoa-bean Price--Actual (LCOBPR) and Forecasted (FOLCOBPR).

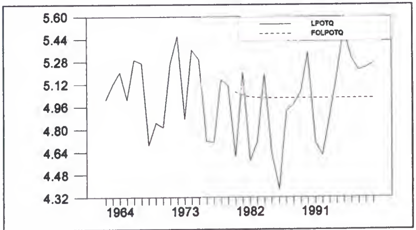

Figure 5.27: Orange Price--Actual (LORPR) and Forecasted (FOLORPR).

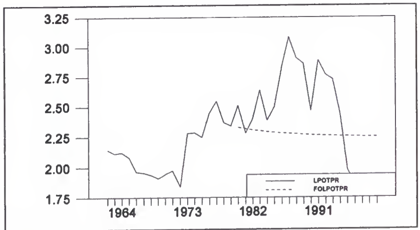

Figure 5.28: Grapefruit Price--Actual (LGRPR) and Forecasted (FOLGRPR).

A second approach was used to construct a counterfactual in order to assess the impact of the economic reforms in Jamaica. In this approach, the actual observations were divided into two separate sub-samples, 1962-1979 and 1980-1999, corresponding to the pre-reform and reform periods, respectively. Supply functions for each crop were estimated for each of the two sub-samples. The estimation procedure followed the Johansen method, which was outlined in chapter 4. Fitted values from the 1962-1979 period were then forecasted over the 1980-1999 period and these forecasts were used as the counterfactuals against which the fitted values from the 1980-1999 supply functions were compared graphically.

With respect to the forecasting exercise, the BOXJENK, CORRELATE, and FORECAST instructions in the RATS computer software were used to identify, estimate and forecast the fitted series which were used as the counterfactual series. After some experimentation, the forecasts were modeled as mixed autoregressive-moving average processes, denoted as ARMA(p, q), where p and q are the autoregressive and moving average orders, respectively (Pindyck and Rubinfeld, 1991).

Following the Box-Jenkins methodology (Enders, 1995; Doan, 1996), the orders of p and q were determined by examining the sample autocorrelation functions (ACF),

partial auto-correlations functions (PACF), and graphs of the fitted series. For each series, several models were fitted to the data and the final choice was determined on the basis of parsimony, and various diagnostic statistics. The test criteria used are the root-mean-square error (RMSE), Theil's Inequality Coefficient (Theil U), and the Ljung-Box Q-statistics. Low RMSE is a desirable quality from a forecasting model. The Theil U statistic is independent of the units of measurement. It is the ratio of the RMSE for the forecast model to the RMSE for a "naïve" forecast of no change in the dependent variable from the previous value (Doan, 1996). Values of Theil U that are less than one indicate that a model performs better (i.e., has a lower RMSE) than the naïve model. Doan (1996) claims that a Theil U of 0.8 or less is reasonable for a univariate forecast model.

The values of (p, q) were determined by the ACF and PACF. For an ARMA(p, q) process, the ACF begins to decay at lag q, and the PACF begins to decay at lag p. In addition to the ACF and PACF, the Ljung-Box Q-statistic was used in model selection. The Q-statistic is a chi-square (χ^2) test used to test the null hypothesis of no significant autocorrelations. The diagnostic statistics for the forecasts of fitted values are reported in Table 5.3.

Table 5.3: Diagnostic Statistics for Forecasts of Fitted Values.

Crop	RMSE	Theil U	Q(2)[a]	Q(4)[a]
Banana	0.167	0.353	3.397	3.963
Sugar	4.799	0.524	0.062	0.266
Coffee	0.378	0.880	0.061	0.368
Pimento	0.094	0.838	2.304	3.559
Yam	0.190	0.538	0.177	3.596
Orange	0.710	0.598	2.324	5.878
Cocoa-bean	5.769	1.188	0.902	4.558
Potato	0.325	0.262	1.957	3.095

[a] Ljung-Box Q-statistics. χ^2_2 and χ^2_4 critical values at 95% level are 5.99 and 9.49 respectively.
RMSE = Root Mean Square Error.

The estimated α and β vectors for each crop for the two sample periods are reported in Tables 5.4 and 5.5, respectively. From Table 5.4 the most economically plausible equations (i.e., equations that meet *a priori* (sign) expectations) were selected to generate fitted values for the dependent variable in each crops' ECM for the 1962-79 period. For example, the fitted values for banana for the 1962-79 period were estimated as follows:

$$\text{BANFIT} = .300 + 0.781{*}P_o - 0.242{*}P_a - 0.758{*}W - 0.854{*}F$$

where all coefficients are taken from the CE #1 relation for β for banana in Table 5.4. These fitted values were then forecasted, using the methodology described above, over the 1980-99 period, and used as the counterfactual for banana.

In a manner similar to that described above, the fitted values for each crops' ECM were estimated for the 1980-99 period. For example, the fitted values for banana for the 1980-99 period were estimated as follows:

$$BANFITA = -4.140 + 0.172*P_o - 0.103*P_a - 0.040*W - 0.003*F$$

where all coefficients are taken from the CE #2 relation for β for banana in Table 5.5. The `A' appended to `BANFITA' is used to denote that the actual observations, P_o, P_a, W and F, were used to estimate the fitted series.

The two sets of fitted values, the (forecasted) `counterfactual' and `actual', for each crop, were then plotted on the same graph. These graphs are shown in Figures 5.29-5.36. From a visual inspection of those graphs the following observations are noted. First, banana is the only crop in the sample for which the fitted values from the reform period are clearly above the fitted values for the counterfactual over the entire 1980-1999 period. Excluding the years 1987-1988, this observation is also applicable for pimento. The interpretation of this observation, based upon the assumptions that have been used to generate the fitted and forecasted series, is that if there were no change in the policy regime in Jamaican over

Table 5.4: Estimated Long-run and Adjustment Coefficients, β's, α's for all Crops, 1962-1979.

Crops	Q	P_o	P_a	W	F	C
Banana						
CE #1						
β's	1	0.781	-0.242	-0.758	-0.854	0.300
α's	-0.110 (-1.711)[c]	-0.267 (-1.372)[c]	0.368 (2.018)[b]	0.174 (4.691)[a]	-0.008 (-0.084)	
CE #2						
β's	1	0.196	0.017	1.385	-0.170	-12.477
α's	-0.140 (-1.560)[c]	0.166 (0.611)	0.327 (1.288)	-0.109 (-2.122)[b]	0.560 (4.270)[a]	
Sugar						
β's	1	0.195	-0.654	-0.282	-0.697	-2.053
α's	-0.153 (-1.792)[c]	-0.542 (-2.327)[b]	0.276 (1.099)	0.209 (3.929)[a]	0.123 (0.763)	
Coffee						
CE #1						
β's	1	0.516	-0.176	-0.310	-0.108	-7.862
α's	-0.350 (-1.597)[c]	-0.242 (-1.040)	1.052 (5.714)[a]	0.089 (1.118)	0.067 (0.604)	
CE #2						
β's	1	-0.778	-0.101	-0.980	2.325	-0.938
α's	-0.066 (-0.880)	0.082 (1.039)	0.065 (1.035)	0.011 (0.393)	-0.190 (-5.061)[a]	
Pimento						
CE #1						
β's	1	-0.018	-0.070	0.757	0.261	-9.838
α's	-0.846 (-4.823)[a]	0.346 (1.956)[b]	0.145 (0.622)	-0.008 (-0.127)	-0.371 (-3.379)[a]	
CE #2						
β's	1	0.364	-0.640	-0.685	-1.397	-14.232
α's	-0.391 (-2.821)[a]	-0.631 (-4.509)[a]	0.253 (1.375)[c]	0.051 (1.045)	0.114 (1.317)	
Yam						
CE #1						
β's	1	-3.303	5.672	1.637	1.685	-30.596
α's	-0.083 (-2.914)[a]	0.135 (2.284)[b]	-0.119 (-3.671)[a]	-0.000 (-0.005)	-0.111 (-2.373)[b]	
CE #2						
β's	1	1.879	-1.587	-1.223	-2.433	-27.495
α's	-0.134 (-4.415)[a]	-0.016 (-0.261)	0.043 (1.260)	0.910 (0.385)	0.090 (1.814)[b]	
Orange						
CE #1						
β's	1	2.356	-3.034	-2.910	-0.949	15.925
α's	-0.062 (-0.897)	0.227 (1.549)[c]	-0.086 (-0.502)	0.028 (1.327)	0.142 (4.666)[a]	
CE #2						
β's	1	0.723	-1.417	0.570	-1.791	-3.193
α's	-0.203 (-1.916)[b]	0.210 (0.939)	-0.169 (-0.649)	-0.030 (-0.946)	0.123 (2.662)[b]	

Table 5.4: Cont'd.

Crops	Q	P_o	P_a	W	F	C
Cocoa-bean CE #1 β's	1	-0.313	0.035	0.603	1.018	-9.430
α's	-1.218 (-4.036)[a]	1.270 (2.750)[b]	-0.771 (-1.848)[b]	-0.055 (-0.448)	-0.257 (-1.756)[c]	
CE #2 β's	1	2.802	-1.204	-3.546	-0.148	8.720
α's	-0.033 (-0.994)	-0.112 (-2.227)[b]	0.022 (0.479)	0.003 (0.244)	0.103 (6.455)[a]	
Potato CE #1 β's	1	1.396	-2.698	0.820	-1.183	-6.713
α's	-0.099 (-0.653)	-0.018 (-0.201)	0.212 (5.015)[a]	-0.006 (-0.218)	0.242 (4.597)[a]	
CE #2 β's	1	1.592	-7.377	-4.172	-3.103	31.003
α's	-0.048 (-0.667)	-0.034 (-0.825)	0.034 (1.726)[b]	0.044 (3.386)[a]	0.055 (2.226)[b]	

Note: Figures in parentheses are t-values.
CE indicates 'cointegration equation'.
[a], [b], [c], indicate statistical significance at one, five and ten percent levels, respectively.
Q = quantity; P_o = own-price; P_a = price of the alternative crop; W = average wage rate in agriculture sector; F = average price of fertilizer; C = constant (intercept).

Table 5.5: Estimated Long-run and Adjustment Coefficients, β's, α's for all Crops, 1980-1999.

Crops	Q	P_o	P_a	W	F	C
Banana						
CE #1						
β's	1	-0.249	0.255	-0.006	0.921	-6.383
α's	-0.135 (-1.534)	0.093 (0.230)	-1.942 (-3.814)[a]	0.344 (2.532)[b]	-0.805 (-3.891)[a]	
CE #2						
β's	1	0.172	-0.103	-0.040	-0.003	-4.140
α's	-1.047 (-4.456)[a]	-2.308 (-2.150)[b]	1.043 (0.769)	0.310 (0.858)	0.559 (1.015)	
CE #3						
β's	1	0.306	0.069	0.029	0.916	-7.344
α's	-0.064 (-2.788)[b]	-1.064 (-2.880)[a]	-0.176 (-0.376)	-0.162 (-1.301)	-1.122 (-5.918)[a]	
Sugar						
CE #1						
β's	1	0.255	-0.249	-0.006	-0.921	5.879
α's	-0.135 (-2.534)[b]	-1.942 (-3.814)[a]	0.093 (0.230)	0.344 (2.532)[b]	-0.805 (-3.891)[a]	
CE #2						
β's	1	0.103	-0.172	-0.040	-0.003	-3.636
α's	-1.047 (-4.456)[a]	-1.043 (-0.769)	2.308 (2.150)[b]	0.310 (0.858)	0.559 (1.015)	
CE #3						
β's	1	0.069	0.306	0.029	0.916	-6.839
α's	-0.064 (-0.788)	-0.176 (-0.376)	-1.064 (-2.880)[a]	-0.162 (-1.301)	-1.122 (-5.918)[a]	
Coffee						
CE #1						
β's	1	-1.140	2.259	0.956	6.905	-25.382
α's	-0.127 (-1.792)[c]	0.087 (1.467)	-0.143 (-2.749)[b]	-0.018 (-0.600)	-0.193 (-7.023)[a]	
CE #2						
β's	1	1.108	-0.231	-0.440	-0.116	-6.146
α's	-0.016 (-0.066)	-0.711 (-3.460)[a]	0.717 (3.972)[a]	0.031 (0.301)	0.223 (2.339)[b]	
Pimento						
CE #1						
β's	1	-0.190	1.410	0.907	1.680	-15.165
α's	-0.048 (-0.446)	0.286 (4.779)[a]	-0.380 (-3.760)[a]	-0.015 (-0.281)	-0.127 (-2.111)[b]	
CE #2						
β's	1	0.282	-0.406	-1.181	-0.388	-9.764
α's	-0.769 (-5.208)[a]	-0.096 (-1.186)[c]	0.087 (2.629)[b]	0.021 (0.293)	0.010 (0.125)	

Table 5.5: Cont'd.

Crops	Q	P_o	P_a	W	F	C
Yam						
CE #1						
β's	1	2.543	-3.168	-0.052	-0.543	-7.369
α's	-0.131 (-2.183)[b]	-0.391 (-3.944)[a]	0.030 (2.464)[b]	0.075 (1.301)	0.012 (0.100)	
CE #2						
β's	1	0.356	-0.248	1.805	0.503	-18.315
α's	-0.253 (-3.344)[a]	-0.744 (-5.960)[a]	0.384 (4.703)[a]	-0.179 (-2.470)[a]	-0.193 (-1.246)	
CE #3						
β's	1	-0.301	0.469	0.122	0.980	-11.136
α's	-0.336 (-3.850)[a]	0.564 (3.928)[a]	-0.099 (-1.049)	-0.024 (-0.286)	-0.453 (-2.533)[b]	
Orange						
CE #1						
β's	1	-5.652	4.301	-4.485	-4.097	32.444
α's	-0.047 (-1.001)	0.089 (0.816)	-0.306 (-5.225)[a]	0.059 (2.889)[a]	0.049 (1.496)	
CE #2						
β's	1	0.224	-0.477	-0.115	-1.609	-0.501
α's	-0.271 (-1.789)[c]	-1.347 (-3.846)[a]	1.369 (7.267)[a]	0.017 (0.260)	0.237 (2.240)[b]	
CE #3						
β's	1	0.050	-0.307	1.185	0.468	1.084
α's	-0.197 (-1.147)	-0.576 (-1.446)	0.453 (2.114)[b]	0.049 (0.655)	-0.527 (-4.348)[a]	
Cocoa-bean						
CE #1						
β's	1	0.016	-1.159	-0.505	-2.212	-0.353
α's	-0.153 (-0.884)	-0.384 (-2.326)[b]	0.432 (2.107)[b]	0.098 (1.027)	0.603 (4.688)[a]	
CE #2						
β's	1	-0.302	-0.362	1.106	0.471	-10.230
α's	-1.831 (-5.336)[a]	0.558 (1.708)[c]	0.532 (1.312)	-0.179 (-0.952)	-0.216 (-0.851)	
Potato						
CE #1						
β's	1	0.971	-1.274	-2.240	-0.702	17.404
α's	-0.081 (-0.942)	-0.083 (-1.295)	0.136 (5.318)[a]	0.032 (1.928)[c]	0.049 (1.019)	
CE #2						
β's	1	-0.008	0.612	0.030	0.303	-6.541
α's	-0.917 (-1.239)	0.472 (0.855)	-0.225 (-1.016)	-0.179 (-1.263)	-0.138 (-0.331)	

Note: Figures in parentheses are t-values.
CE indicates 'cointegration equation'.
[a], [b], [c], indicate statistical significance at one, five and ten percent levels, respectively.

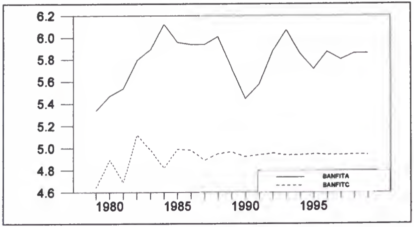

Figure 5.29: Banana--Fitted Output for Reform Period (BANFITA) and Counterfactual (BANFITC).

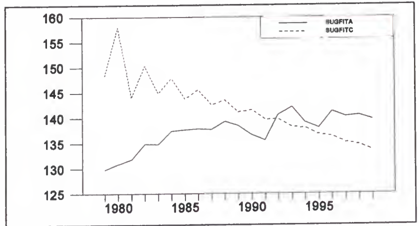

Figure 5.30: Sugar--Fitted Output for Reform Period (SUGFITA) and Counterfactual (SUGFITC).

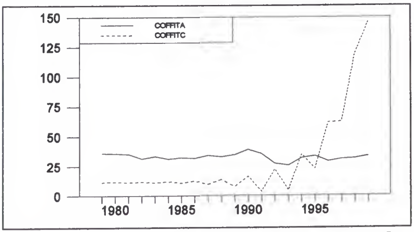

Figure 5.31: Coffee--Fitted Output for Reform Period (COFFITA) and Counterfactual (COFFITC).

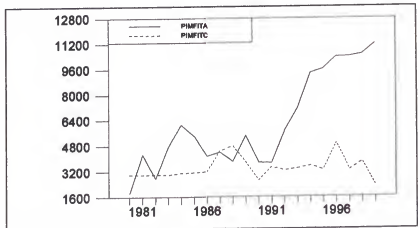

Figure 5.32: Pimento--Fitted Output for Reform Period (PIMFITA) and Counterfactual (PIMFITC).

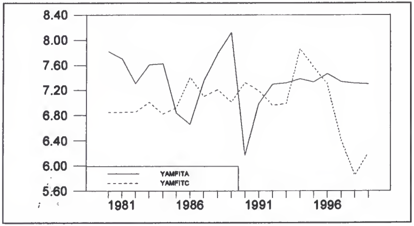

Figure 5.33: Yam--Fitted Output for Reform Period (YAMFITA) and Counterfactual (YAMFITC).

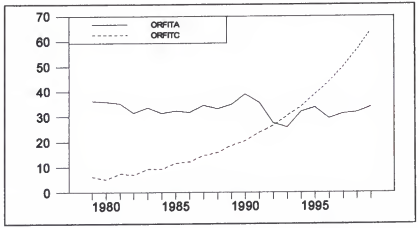

Figure 5.34: Orange--Fitted Output for Reform Period (ORFITA) and Counterfactual (ORFITC).

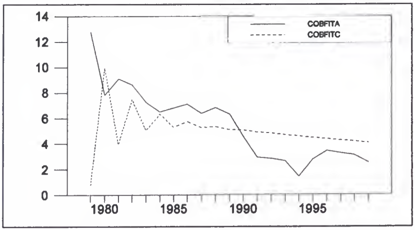

Figure 5.35: Cocoa-bean--Fitted Output for Reform Period (COBFITA) and Counterfactual (COBFITC).

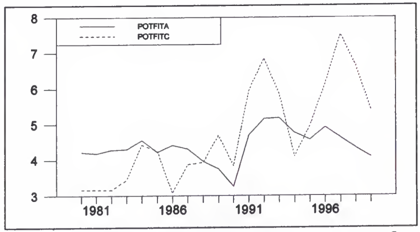

Figure 5.36: Potato--Fitted Output for Reform Period (POTFITA) and Counterfactual (POTFITC).

the 1980-1999 period, then the output of banana and pimento, with given price incentives, would have been lower than that which were actually observed under the reform policy regime. In other words, it appears that the reforms impacted positively on these two crops over the 1980-1999 period.

Second, for some crops there are two distinct periods over 1980-1999 in which the fitted values from the reform period are either above or below the counterfactual. For example, over the 1980-1992 period the fitted values for sugar for the reform period were below those for the counterfactual. The reverse is observed for the series since 1992. Similarly, fitted values for coffee for the reform period have been above the counterfactual over the 1980-1995 period but the situation reversed after 1995. Similar observations can be made for orange and cocoa-bean.

Finally, the cases of yam and potato are different from the two patterns observed for the other crops. Yam shows an oscillating pattern. Fitted values for the counterfactual were below fitted values for the reform period over 1980-1985. Potato showed similar oscillations but with relatively wider gaps within each oscillation.

In effect, therefore, based on the counterfactual analysis, the data seem to suggest that the impact of the

reforms are crop and time specific. For some crops it would appear that the reforms impacted negatively on output trends in the 1990s. This is the case of coffee, orange, cocoa-bean and potato. For banana and pimento the reforms appear to impact positively on output responses. For yam and potato, similar straightforward conclusions cannot be made since the reforms appear to impact positively on output response in some periods and negatively in others.

5.3 Summary

Comparative analysis of crop output and prices between the pre-reform and reform periods suggests a mixed record regarding the impacts of economic reforms in Jamaican agriculture. For some crops, mean output increased under the reform periods, while for others, output contracted. Clear evidence of greater price variability is observed in the reform period compared to the pre-reform era. The counterfactual analysis suggests that the effects of the reforms are crop and time dependent.

CHAPTER 6
CONCLUSIONS AND POLICY IMPLICATIONS

Jamaica embarked upon a process of economic policy re-orientation in the late 1970s, at a time when the economy was showing signs of acute economic crisis. Mainly the IMF and World Bank sponsored the economic reforms in consultation with the Jamaican government. Although, at various points in time, there were clear signs of opposition by the government towards the economic reforms emanating from the Bretton Woods Institutions, by 1990, Jamaica had, to a large degree, embraced most of the reform policies.

Essentially pragmatic, the reforms highlighted the need for a more outward orientation of the Jamaican economy. Much emphasis has been placed on being competitive in world markets and also upon relying on market forces to determine prices and to allocate increasingly scarce capital resources. The reforms also entailed a critical re-assessment of the role of the state in terms of its size, overall efficiency, and its relationships with the private sector. As a result of these considerations, topics such as

deregulation, privatization and economic liberalization acquired increased attention in the policy debates over the past two decades.

The reforms that began in the late 1980s engendered an entirely new economic environment for agriculture. However, it posed numerous challenges to economic agents such as small farmers and other agricultural producers generally, who had hitherto operated under various subsidies and guaranteed marketing and pricing schemes. In this regard, one government agency reports that

> Since the liberalization of the economy and the subsequent restructuring of government support for essential services in the agricultural sector, farmers have had some problems remaining competitive. (Jamaica, Planning Institute of Jamaica, 1996, p.7.12)

The quotation above is instructive insofar as it may have identified an important aspect of economic reality in Jamaica, namely, the difficulty of farm producers to make a successful transition between policy regimes, which in many respects make differential demands on economic actors. This conclusion achieves some degree of plausibility in light of the observation that the transformation or re-ordering of economic policy priorities constitutes a fundamental departure from the basic policy directives that had been adopted in Jamaica from the 1960s through to the late 1970s. These policies encouraged inward looking industrial-

ization; state-sponsored import substitution and nationalization of foreign enterprises; extensive use of price controls and subsidies; and, generally, a relatively strong populist approach to the solution of poverty, low income, unemployment, and other socio-economic problems.

One of the principal tasks of this study has been to investigate the impact of the economic reforms on crop supply response in Jamaica. The estimates on crop supply responses presented in this study suggest that long-run equilibrating relationships exist which link crop output and price incentives for the eight crops studied. This result has important policy implications insofar as it indicates a significant relationship between agricultural supply and price incentives. In particular, and on the basis of the analytical method used in this study, the link between output and price incentives means that these variables move together over time and more importantly, respond to the same shocks in the system, albeit with varying degrees. Further, as markets become more competitive, this link becomes stronger since market signals are transmitted more effectively and efficiently.

Although economic theory is generally silent as to what constitutes a stimulative price shift for agricultural producers, the econometric evidence presented in this study

indicates a positive relationship between output supply and own-price. Crops such as banana and sugar, whose prices are still determined by preferential agreements, enjoyed increased real prices over the reform period. Jamaican sugar and banana have guaranteed access to the European Union (EU) market via the Lome Conventions. The prices paid for Jamaican exports in this market are significantly higher than world market prices. However, the EU's Common Agricultural Policy (CAP) requires progressive reductions of subsidies to African Caribbean and Pacific (ACP) countries. This is expected to reduce the prices paid for ACP exports.

In addition, with respect to bananas, EU's arrangements with the ACP countries are constantly being challenged by Central and Latin American (Dollar) banana countries. Proposals are for the individual ACP quotas to be replaced by a single global ACP group quota. While the tariff preference is expected to continue in the future, it is under constant review. The main implication is that Jamaican farmers must reduce cost of production in order to compete in the EU market.

The twin issues of reducing cost of production and achieving international competitiveness appear to be major goals in the government's National Industrial Policy which

was tabled in 1996. In this regard, J$750 million in international funding was sourced and allocated to various projects in response to the frequent debates in the EU to reduce preferential treatments of ACP exports (Jamaica, Planning Institute of Jamaica, 1998). In the case of banana, various projects have been implemented since the mid-1990s. These include programs for improved management of water systems and the banana disease, Sigatoka. For small and medium size farms, high cost and unavailability of inputs are major constraints to improving productivity. For these farmers the government has invested J$38 million to set up a supply store and has established a revolving loan scheme for improvements in irrigation and other infrastructural works. In addition, other projects have been implemented which aim at improving banana quality, such as experiments in de-handling, deflowering, bunch hardening, and packaging and storage.

There is strong evidence to suggest that there are considerable constraints in the economic system, which slow down the adjustment process for economic variables. This is evidenced by the prevalence of low adjustment coefficients, which were estimated along with the long-run relationships. Own-price and quantity adjustments appear to exercise the major weight in the adjustment of the short-run to the

long-run equilibrium process. While significant elasticities were observed for the input prices, generally these were low, but fall within the range of estimates reported in other studies on supply response in Jamaica. The low input price elasticities are not surprising since inputs such as wages and fertilizer constitute important components in the production process. However, if these inputs are not to appear as constraints to production, policy initiatives have to be undertaken to make them appealing to producers.

Given the biological lag between planting and harvesting seasons in agriculture, adjustments in the sector are necessarily slow processes. Additional factors that contribute to slow adjustments are the institutional and structural framework within which agricultural producers must operate. Slow adjustments in the short-run are signs of constraining government regulations, inadequate supportive infrastructure, and lack of credit to farmers. Although not explicitly incorporated in the modeling framework used in this study, these factors have been listed by farmers in coffee, cocoa-bean, citrus and yam production as major constraints to increasing output (Jamaica, Planning Institute of Jamaica, 1994, 1996, 1998).

In an earlier section of this study, some of these factors were identified as the conduits through which policies are transmitted to target variables. It appears that the government has been aware of these problem as can be gleaned from the following quotation:

> For positive growth in the sector to be sustained, there is urgent need for infrastructural development and a strengthening of research and extension services… This need has assumed an increasing sense of urgency in light of pending changes on the global economic landscape with the new General Agreement on Tariffs and Trade (GATT). (Jamaica, Planning Institute of Jamaica, 1994, p.7.1)

To the extent that this is true, further improvements in crop supply response would be conditional upon the intensification and broadening of the reform process in agriculture. Indeed, the general decline in agricultural production since the mid-1990s, prompted the government to outline policy guidelines aimed at correcting some of the problems impacting the sector. These guidelines emphasized improving the competitiveness of traditional and non-traditional exports in international markets; creating an enabling environment for farmers through additional capital funding over the long, medium and short-run period; implementation of projects/programs aimed at improving production and productivity for local and export markets; and improving support services (Jamaica, Planning Institute of Jamaica, 1998).

While it may appear that government policies are being implemented to facilitate the farmer to operate in the new policy environment, budgetary constraints may not always permit an effective solution. For example, in light of increasing demands by farmers for agricultural credit at concessionary rates, the government offered agricultural loans at subsidized rate (13 percent). However, loans allocated to farmers have dropped almost 50 percent over the past five years because of budgetary constraints.

The empirical evidence provides only partial support for the hypothesis that the reforms impacted significantly on agricultural supply responses. In particular, even when controlling for policy regime changes by constructing counterfactuals against which the reforms could be compared, it was found that for the eight crops included in this study, the effects are crop and time dependent.

Although nominal crop prices have increased dramatically during the reform period, real crop prices have remained stable or have declined generally. Movements in the exchange rate and the general price level seem to be the immediate causes for these phenomena. It appears also that price variability increased significantly during the reform period. Given that farmers in Jamaica, as in most developing countries, can rarely mitigate against temporal

price risk, the evidence seems to suggest that the pro-competitive effects of the reforms may have acted more as a depressive factor on supply response, compared to the stability of the pre-reform period characterized by stable and guaranteed markets and prices by government commodity boards.

A relevant question which may be posed here is how representative is the sample of crops which was chosen for the study. The eight crops were not randomly chosen but were selected the same way a researcher might have chosen to study just one of the crops. However, the crops included in the study include the most important traditional export crops of Jamaica. It is unlikely that any of these crops would have been insulated from the economic reforms over the past two decades. However, whether the conclusions from this study can be generalized for the other crops that are grown in Jamaica, is an empirical question.

Further insights into the impact of the reforms on crop supply responses in Jamaica would be obtained by more intensive study of single crops. This will allow more in-depth study, and guard against using the same modeling framework to accommodate crops whose supply dynamics may be different.

APPENDIX A
PRICE DATA USED IN CROP'S ECM ON JAMAICA, 1962-1999 (J$)

Year	banana	sugar	coffee	pimento	yam	orange	Cocoa-bean	potato
1962	28	5	542	1050	80	18	210	99
1963	29	5	549	1052	86	21	219	99
1964	29	5	560	1065	88	25	228	102
1965	30	6	570	1075	90	27	232	102
1966	30	6	570	1,102	91	33	236	104
1967	34	6	641	2,121	96	38	263	107
1968	34	6	425	1,047	101	31	276	114
1969	29	6	572	1,102	107	29	265	120
1970	30	6	569	1,165	118	31	272	133
1971	51	7	613	1,102	140	31	344	141
1972	49	8	674	1,146	141	25	350	132
1973	73	9	839	1,005	176	37	369	242
1974	159	11	1,272	1,397	273	57	451	309
1975	188	19	1,784	1,947	342	26	559	350
1976	196	19	1,966	1,994	399	64	566	466
1977	196	21	2,483	1,837	424	78	616	573
1978	175	32	3,560	1,900	424	21	3,590	651
1979	347	45	3,000	2,010	551	42	3,000	816
1980	520	71	2,205	2,100	1,168	104	2,208	1,230
1981	640	102	2,021	2,205	1,224	108	2,991	1,100
1982	700	130	2,572	2,425	1,168	122	2,991	1,320
1983	1,190	239	2,940	2,425	1,345	122	2,991	1,587
1984	1,998	483	3,123	3,417	1,499	208	4,228	1,852
1985	2,065	762	5,144	5,071	1,631	380	5,104	2,601
1986	2,249	908	8,157	7,716	1,764	454	6,022	4,189
1987	2,866	1,249	7,716	8,047	2,557	381	6,482	5,754
1988	2,668	1,354	7,716	8,818	3,527	536	6,941	5,225
1989	2,337	1,849	7,800	9,149	5,842	3,960	6,556	5,688
1990	3,748	4,943	8,000	9,590	4,410	2,860	6,756	4,670
1991	7,046	5,324	11,684	11,464	7,980	8,800	7,706	10,780
1992	8,818	9,743	27,925	23,148	12,050	30,800	8,000	16,950
1993	11,000	10,957	27,355	27,550	14,700	44,660	9,000	19,880
1994	17,637	14,825	30,433	33,460	15,000	45,000	10,000	20,000
1995	20,073	18,120	43,333	34,171	11,400	45,522	21,000	15,200
1996	17,813	20,456	43,333	36,376	11,562	45,521	21,987	16,982
1997	17,680	17,170	43,333	45,194	11,256	45,987	21,558	16,989
1998	18,510	16,752	46,065	50,706	11,789	45,887	22,154	17,586
1999	22,522	17,635	48,221	52,602	12,156	45,978	22,546	17,892

Source: (1) 1962-65, 1995-1999: Jamaica, Statistical Institute of Jamaica, (STATIN), (Data Files) (2) 1966-1995: Food and Agricultural Organization (FAO). FAOSTAT Agricultural Data. http://fao.org. August, 1998.

APPENDIX B

QUANTITY DATA USED IN CROPS' ECM, 1962-1999 (METRIC TONNES)

Year	banana	sugar	coffee	pimento	yam	orange	Cocoa-bean	potato
1962	221741	523215	1721	3012	61245	73125	1542	10257
1963	210523	521000	1785	3012	62546	74552	1945	11450
1964	226331	512663	1798	3111	62946	75489	1854	12453
1965	231046	505621	1852	3125	63012	78562	1945	10254
1966	240,400	508,247	1,861	3,200	63,486	79,772	2,174	13,608
1967	234,200	455,815	1,991	4,500	74,580	82,236	1,642	13,297
1968	198,000	451,895	1,972	4,800	66,306	85,085	1,864	7,454
1969	196,000	389,124	1,589	3,800	62,556	73,304	1,857	8,717
1970	195,000	376,057	1,805	2,671	80,825	65,142	2,163	8,440
1971	187,000	385,029	1,358	3,510	122,864	72,726	1,872	13,207
1972	198,000	379,214	1,040	3,290	127,489	83,160	2,378	16,132
1973	169,000	331,181	1,146	3,410	127,650	23,408	1,952	8,941
1974	132,000	372,391	1,486	3,570	131,323	39,309	1,618	14,606
1975	127,000	360,578	1,186	3,320	134,254	40,849	1,780	13,617
1976	140,000	368,737	1,929	4,970	119,566	41,234	1,646	7,643
1977	160,000	295,237	1,208	3,320	124,941	42,042	1,692	7,579
1978	160,000	291,541	1,477	3,830	149,767	49,665	1,797	11,794
1979	170,000	283,084	958	2,340	157,169	31,224	1,366	11,331
1980	140,000	231,800	2,216	1,840	132,893	43,159	1,752	6,848
1981	150,000	225,000	1,379	4,266	136,410	33,000	1,752	12,428
1982	160,000	195,531	1,516	2,759	116,978	32,879	2,408	6,667
1983	160,000	198,202	1,632	4,729	130,633	31,686	2,302	7,603
1984	155,000	187,791	1,745	6,109	149,060	28,298	2,812	12,310
1985	150,000	225,492	1,274	5,390	163,763	42,119	2,380	7,075
1986	145,000	206,136	1,697	4,162	165,633	41,850	2,406	5,439
1987	140,000	188,985	1,658	4,412	175,628	75,460	3,186	9,443
1988	135,000	221,706	2,231	3,834	166,864	50,820	1,549	9,893
1989	130,000	204,915	1,260	5,444	133,281	57,750	1,386	10,818
1990	127,660	208,592	1,560	3,770	161,462	82,236	2,104	14,296
1991	134,000	235,904	2,280	3,750	186,104	61,908	1,750	7,548
1992	130,000	228,024	1,920	5,730	214,386	70,000	2,478	6,935
1993	125,000	219,046	1,500	7,120	221,928	72,000	2,522	9,134
1994	120,000	223,041	2,460	9,370	233,912	72,546	2,576	12,188
1995	130,000	248,558	2,580	9,630	240,371	72,892	2,538	17,036
1996	130,000	237,943	2,580	10,370	253,371	73,452	1,407	13,775
1997	130,000	236,510	2,887	10,400	212,567	74,561	1,653	12,661
1998	130,000	179,251	3,104	10,542	198,402	74,987	1,687	12,875
1999	130,000	223,000	3,412	11,221	201,354	75,984	1,702	13,256

Source: (1) 1962-65, 1995-1999: Jamaica, Statistical Institute of Jamaica, (STATIN), (Data Files) (2) 1966-1995: Food and Agricultural Organization (FAO). FAOSTAT Agricultural Data. http://fao.org. August, 1998.

APPENDIX C
SELECTED ECONOMIC STATISTICS ON JAMAICA

Year	Adef	ferp	rwage	Cpi80	gdef	ER
1962	13.50	144	208.74	11.60	0.40	0.71
1963	13.80	138	209.58	11.95	0.40	0.71
1964	14.10	139	210.28	12.20	0.40	0.71
1965	14.50	138	212.34	12.71	0.40	0.71
1966	15.90	124	216.42	14.60	0.50	0.71
1967	16.70	137	255.69	15.16	0.50	0.83
1968	17.40	132	289.11	16.43	0.60	0.84
1969	19.70	142	300.95	17.78	0.80	0.83
1970	20.50	146	289.13	19.01	0.90	0.84
1971	20.40	144	299.33	19.58	0.90	0.78
1972	20.10	149	325.47	21.03	0.90	0.85
1973	23.90	193	307.26	24.81	1.10	0.91
1974	31.37	229	302.97	31.53	1.40	0.91
1975	38.13	298	362.47	37.04	1.80	0.91
1976	44.75	339	361.25	40.64	1.90	0.91
1977	52.40	492	354.16	45.02	2.20	0.91
1978	72.09	778	326.04	60.97	2.70	1.70
1979	86.54	1,007	264.19	78.79	3.20	1.78
1980	100.00	1,158	234.02	100.00	3.80	1.78
1981	103.67	1,228	221.24	112.75	4.10	1.78
1982	110.58	983	231.40	119.92	4.50	1.78
1983	133.06	966	244.66	113.86	5.20	3.28
1984	198.67	1,149	235.83	170.91	7.00	4.93
1985	249.27	1,582	262.21	215.14	9.20	5.48
1986	316.83	1,820	277.54	247.41	10.80	5.48
1987	354.07	2,013	316.75	263.75	12.00	5.50
1988	413.28	1,913	340.99	285.66	13.60	5.48
1989	442.73	2,697	314.55	326.27	15.30	6.48
1990	546.16	4,636	268.05	398.45	18.90	8.04
1991	835.26	6,776	182.63	601.99	27.90	21.49
1992	869.95	7,704	175.35	1,066.93	44.40	22.19
1993	893.32	7,725	179.30	1,302.79	59.70	32.48
1994	804.54	13,904	206.60	1,759.36	78.40	33.20
1995	841.98	19,017	218.66	2,109.56	100.00	39.62
1996	879.42	18,136	213.69	2,666.53	121.10	34.87
1997	886.67	21,176	238.27	2,934.30	134.30	41.02
1998	897.56	20,254	270.68	2,942.14	154.00	42.40
1999	909.78	21,924	298.20	3,023.26	159.00	42.84

Sources: (1) Data files, Jamaica, Statistical Institute of Jamaica (STATIN); (2) Jamaica, Planning Institute of Jamaica (various issues).

Notes: Adef = Agricultural deflator (1980=100); ferp = Average price of fertilizer; rwage = index of average agricultural real wage (1980=100); CPI80 = consumer price index (1980=100); gdef = GDP deflator (1980=100); ER = Jamaican exchange rate ($J/US).

APPENDIX D
DIAGNOSTIC STATISTICS FOR MODEL SPECIFICATION AND TEST STATISTICS FOR COINTEGRATION

Table D-1: Tests of Cointegration Rank for Sugar ECM.

Eigen values	λmax	Trace	Ho:r	P-r	λmax 90	Trace 90
0.649	37.66	80.99	0	5	21.73	71.66
0.369	16.56	43.33	1	4	18.03	49.92
0.332	14.54	26.77	2	3	14.09	31.88
0.220	8.96	12.23	3	2	10.29	17.79
0.087	3.27	3.27	4	1	7.50	7.50

Table D-2: Diagnostic Statistics for Residual Tests for the Sugar ECM.

Tests	Df[a]	χ^2	p-value
For normality of residuals	10	15.108	0.10
For autocorrelation			
L-B(9)	195	124.208	0.21
LM(1)	25	23.084	0.57
LM(4)	25	21.299	0.68
For ARCH(2)			
lsugq	2	1.825	
lsugpr	2	0.441	
lbanpr	2	1.555	
lwage	2	0.919	
lferp	2	4.600	

Notes: The critical value for $\chi^2(2) = 5.99$
At the 95 percent significance level.
[a] Df = degrees of freedom.

Table D-3: Tests of Cointegration Rank for Coffee ECM.

Eigen value	λMax	Trace	Ho:r	P-r	λMax 90	Trace 90
0.675	40.44	88.74	0	5	21.74	71.66
0.497	24.72	48.30	1	4	18.03	49.92
0.289	12.30	23.58	2	3	14.09	31.88
0.189	7.56	11.28	3	2	10.29	17.79
0.098	3.72	3.72	4	1	7.50	7.50

Table D-4: Diagnostic Statistics for Residual Tests for the Coffee ECM.

Tests	Df[a]	χ^2	p-value
For normality of residuals	10	11.349	0.33
For autocorrelation			
L-B(9)	190	238.190	0.20
LM(1)	25	38.821	0.06
LM(4)	25	26.303	0.39
For ARCH(2)			
Lcofq	2	2.763	
Lcofpr	2	4.747	
Lbanpr	2	0.086	
Lferp	2	2.478	
Lwage	2	1.345	

Notes: The critical value for $\chi^2(2) = 5.99$ at the 95 percent significance level.

[a] Df = degrees of freedom.

Table D-5: Tests of Cointegration Rank for Pimento ECM.

Eigen value	λMax	Trace	Ho:r	P-r	λMax 90	Trace 90
0.608	33.75	81.34	0	5	21.74	71.66
0.438	20.74	47.59	1	4	18.03	49.92
0.284	12.00	26.85	2	3	14.09	31.88
0.263	10.99	14.85	3	2	10.29	17.79
0.102	3.86	3.86	4	1	7.50	7.50

Table D-6: Diagnostic Statistics for Residual Tests for the Pimento ECM.

Tests	Df[a]	χ^2	p-value
For normality of residuals	10	19.394	0.09
For autocorrelation			
L-B(9)	190	212.972	0.06
LM(1)	25	23.861	0.53
LM(4)	25	36.915	0.06
For ARCH(2)			
Lpimq	2	3.255	
Lpimpr	2	1.131	
Lbanpr	2	2.209	
Lferp	2	9.196	
Lwage	2	4.575	

Notes: The critical value for $\chi^2(2) = 5.99$ at the 95 percent significance level.
[a] Df = degrees of freedom.

Table D-7: Diagnostic Statistics for Residual Tests for the Yam ECM.

Tests	Df[a]	χ^2	p-value
For normality of residuals	10	7.472	0.68
For autocorrelation			
L-B(9)	185	214.194	0.07
LM(1)	25	28.044	0.31
LM(4)	25	22.418	0.61
For ARCH(2)			
Lyamq	2	0.337	
Lyampr	2	2.800	
Lcaspr	2	3.434	
Lferp	2	5.101	
Lwage	2	0.065	

Notes: The critical value for $\chi^2(2) = 5.99$ at the 95 percent significance level.
[a] Df = degrees of freedom.

Table D-8: Tests of Cointegration Rank for the Yam ECM.

Eigen value	λMax	Trace	Ho:r	P-r	λMax 90	Trace 90
0.682	41.23	110	0	5	21.74	71.66
0.549	28.66	68.67	1	4	18.03	49.92
0.462	22.31	40.01	2	3	14.09	31.88
0.246	10.17	17.70	3	2	10.29	17.79
0.189	7.53	7.53	4	1	7.50	7.50

Table D-9: Diagnostic Statistics for Residual Tests for the Orange ECM.

Tests	Df[a]	χ^2	p-value
For normality of residuals	10	5.691	0.10
For autocorrelation			
L-B(9)	195	217.078	0.12
LM(1)	25	26.658	0.37
LM(4)	25	30.412	0.21
For ARCH(2)			
Lorq	2	0.088	
Lorpr	2	0.405	
Lgrpr	2	6.827	
Lferp	2	0.797	
Lwage	2	6.931	

Notes: The critical value for $\chi^2(2)$ = 5.99 at the 95 percent significance level.
[a] Df = degrees of freedom.

Table D-10: Tests of Cointegration Rank for Orange ECM.

Eigen value	λMax	Trace	Ho:r	P-r	λMax 90	Trace 90
0.679	40.90	75.90	0	5	21.74	71.66
0.341	15.01	34.99	1	4	18.03	49.92
0.315	13.63	19.99	2	3	14.09	31.88
0.142	5.53	6.36	3	2	10.29	17.79
0.021	0.82	0.82	4	1	7.50	7.50

Table D-11: Diagnostic Statistics for Residual Tests for the Cocoa-bean ECM.

Tests	Df[a]	χ^2	p-value
For normality of residuals	10	15.772	0.09
For autocorrelation			
L-B(9)	195	171.387	0.10
LM(1)	25	18.188	0.83
LM(4)	25	35.577	0.08
For ARCH(2)			
Lcobq	2	0.910	
Lcobpr	2	0.438	
Lbanpr	2	1.278	
Lferp	2	6.781	
Lwage	2	3.322	

Notes: The critical value for $\chi^2(2) = 5.99$ at the 95 percent significance level.
[a] Df = degrees of freedom.

Table D-12: Tests of Cointegration Rank for Cocoa-bean ECM.

Eigen value	λMax	Trace	Ho:r	P-r	λMax 90	Trace 90
0.665	39.41	84.17	0	5	23.72	82.68
0.404	18.65	44.77	1	4	19.88	58.96
0.298	12.74	26.12	2	3	16.13	39.08
0.263	10.98	13.38	3	2	12.39	22.95
0.064	2.39	2.39	4	1	10.56	10.56

Table D-13: Tests for Cointegration Rank for Potato ECM.

Eigen value	λMax	Trace	Ho:r	P-r	λMax 90	Trace 90
0.713	44.92	93.40	0	5	21.74	71.66
0.415	19.30	48.47	1	4	18.03	49.92
0.302	12.92	29.17	2	3	14.09	31.88
0.254	10.55	16.25	3	2	10.29	17.79
0.146	5.70	5.70	4	1	7.50	7.50

Table D-14: Diagnostic Statistics for Residual Tests for the Potato ECM.

Tests	Df[a]	χ^2	p-value
For normality of residuals	10	14.295	0.16
For autocorrelation			
L-B(9)	190	218.901	0.07
LM(1)	25	24.219	0.51
LM(4)	25	22.342	0.62
For ARCH(2)			
Lpotq	2	1.816	
Lpotpr	2	3.973	
Lcaspr	2	1.283	
Lferp	2	1.237	
Lwage	2	1.401	

Notes: The critical value for $\chi^2(2)$ = 5.99 at the 95 percent significance level.

[a] Df = degrees of freedom.

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I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

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